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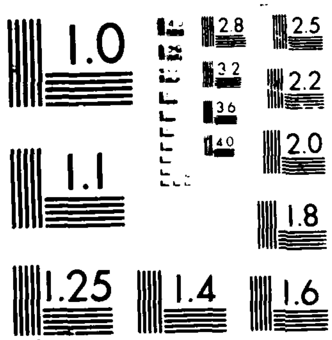
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National Economic Development Procedures Manual - Agricultural Flood Damage

October 1987

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The primary purpose of this report is to provide an expanded description of the agricultural benefit evaluation procedures recommended in the Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies. The report presents specific procedures for the entire process of agricultural benefit estimation and is intended for use in project feasibility planning and evaluation. It is intended to be a reference guide to questions an analyst might have in conducting an agricultural benefit evaluation.

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NATIONAL ECONOMIC DEVELOPMENT PROCEDURES MANUAL
AGRICULTURAL FLOOD DAMAGE

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PREFACE

This manual provides a comprehensive guide for calculating National Economic Development benefits for agricultural flood damage reduction projects. It was prepared by a working committee, with representation from various Corps offices. Mr. William J. Hansen, Water Resources Support Center, Institute for Water Resources (IWR) served as committee chairman and principal author and editor for the manual. Other committee members who served as lead authors for individual chapters include: Mr. Kenneth S. Cooper, Southwestern Division; Mr. Jesse K. McDonald, Lower Mississippi Valley Division; Mr. Ronald C. Roberts, Missouri Valley Division; Mr. Jeffrey L. McGrath and Ms. Jody L. Rooney, St. Paul District; Mr. Michael W. Burnham and Mr. Darryl W. Davis, Water Resources Support Center, Hydrologic Engineering Center; and Mr. Stuart A. Davis, IWR. Mr. Robert M. Daniel, CECW-PD, and Mr. Robert N. Stearns, CECW-RP, also served on the committee and provided technical direction and review during the preparation of this manual.

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CHAPTER I

INTRODUCTION

PURPOSE

The purpose of this manual is to serve as a comprehensive guide for calculating National Economic Development (NED) benefits for agricultural flood damage reduction projects. This document will present specific procedures for the entire process of benefit estimation and is intended for use in project feasibility planning and evaluation. It is intended to b a reference guide to questions an analyst may have. As a practical guide, the manual provides greater emphasis on "how to do it" rather than "why to do it," draws heavily from actual studies, and incorporates numerous suggestions from report writers and reviewers in the Corps of Engineers. The procedures found in this manual should not be construed as the only way the regulations and guidance can be implemented. Appropriate methods should be selected according to requirements of the type of project and planning document, local conditions and needs, availability of information, availability of funding to perform the study, and procedures which have been successful in the past.

This manual is based on the conceptual framework of the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). It will neither duplicate nor supersede P&G, but rather will elaborate on and provide references for how this directive can be carried out.

INTENDED AUDIENCE

This manual is primarily designed for Corps of Engineers planners and comparable staff from our non-Federal project partners. For Corps' economists, this will be a handy guide and quick reference. Other planners, particularly study managers, must be able to thoroughly understand and explain the process of benefit calculation to the public. Additionally, the information in this manual will provide the study manager with enough background to make rational choices for plan optimization and selection. Recent initiatives toward increased involvement by the non-Federal partner in Corps' projects have included 50-50 cost sharing of feasibility studies. This document will familiarize non-Federal sponsors with the procedures traditionally used in Corps economic analysis. Distribution to our partners is encouraged, whether or not they intend to take an active role in the economic analysis portion of the overall study.

SCOPE

This manual is limited to discussion of procedures for estimating the national economic effects of flooding and computing national economic development benefits for agricultural flood damage reduction projects. Under P&G, one of the alternative plans to address the needs and opportunities in water and land related planning must be the NED Plan. The NED Plan reasonably maximizes the net difference between NED benefits and NED costs. NED benefits arise when an investment in water resources increases the Nation's output of goods and services, or reduces the cost of producing these goods and services.

These benefits are measured as the dollar value of the increased output or the dollar value of the reduction in costs. NED costs arise because resources are diverted for the project that would have value in alternative uses. These costs are measured as the dollar value of the resources in their next best alternative use.

The major requirements of NED benefit evaluation for agricultural flood control components of alternative plans may be summarized as follows: for each alternative plan the planning study must estimate NED benefits for crop production, damage reduction for other agricultural properties and associated agricultural enterprises, and off-site sediment reductions. The total for all three categories is the NED Agricultural benefit for the proposed project.

The first step in all crop production evaluations is the identification of land use and cropping patterns with and without implementation of the alternative plan being considered. For land on which the cropping pattern is not expected to change, the benefit is determined by using farm budget analysis. The benefit is estimated by analyzing the production function of farm land under with- and without-project conditions. The net increase (income in this case) attributable to the project is the NED benefit.

For land on which the cropping pattern is expected to change, there are two acceptable methods for estimating NED benefits. The first is, again, farm budget analysis as described above. The second is land value analysis. After completing step one above, the benefit is estimated by comparing with- and without-project land values based on appraised market values, not capitalized income streams. The net increase is the NED benefit.

The second benefit category is damage reduction for other agricultural properties and associated agricultural enterprises. This category would include physical improvements associated with various farm enterprises and the community, and economic activities which may be affected by changed water supply or water management conditions. Evaluation of other agricultural properties is determined by estimating damages expected to the properties under with- and without-project conditions. The reduction in damages in the future with the project, compared to damages in the future without the project, is the NED benefit. Evaluation of associated agricultural enterprises is determined by estimating the difference in net income to the enterprise under with- and without-project conditions.

The final category of agricultural flood control benefits is off-site sediment reduction. Under without project conditions periodic removal of sediment from roadways, culverts, channels, water treatment and other facilities has a predictable annual cost which can be estimated based on historic records. Any reduction in those costs under with-project conditions is considered to be an NED benefit to the proposed project.

Regional Economic Development (RED) benefits account for changes in the distribution of regional activity that result from each alternative plan. While results in this account cannot be used in formulating the NED Plan, they can be extremely helpful to the local partner in identifying direct impacts to the region and in assessing the reasonability and implementability of the alternative under consideration. Effects on RED, both positive and negative, are normally measured in terms of regional income and employment. Due to the definition of region used for the RED account, all or almost all of the NED benefits will accrue to that region. Additionally, transfers of income and employment into the region from elsewhere in the Nation will be included in the RED account. From a national perspective, transfers represent a redistribution of income and employment among the regions and therefore are inappropriate to include in the project benefit-cost ratio. Even so, these transfers may have significant impacts on the local constituency and could have an impact on the alternative recommended for construction. A detailed description of the RED account can be found in Engineer Regulation (ER) 1105-2-30[1], pages A-11 and A-12. This manual will not further discuss RED benefits.

OVERVIEW OF BALANCE OF REPORT

Chapter II describes the planning process for agricultural benefit evaluation as described in P&G. It also identifies and discusses basic concepts, knowledge of which are essential to the proper analysis of this benefit category. Chapter III provides a glossary of relevant terms, discusses the basic concept of agricultural flood damage, and clarifies basic principles associated with agricultural damage analysis. Additionally, a scenario is presented to illustrate the application of the principles discussed. The process used to analyze agricultural crop flood damage is presented in Chapter

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[1]All Engineer Regulations and Circulars cited in this manual are included in the Planning Guidance Notebook (US Army Corps of Engineers, 1982).

IV. Included are descriptions of alternative analytical approaches, needed data and analysis coordination for these alternatives, and guidelines for performing elements of the calculations.

The special concepts and considerations for addressing crop and non-crop damage are presented in Chapters V and VI, respectively. The importance of the seasonality of flooding to crop damage is described in Chapter V. More specifically, the discussion covers how to incorporate the relationship between stage of crop production (from planting to harvesting) and timing of flooding (when during the growing season) into the analysis. Chapter VI provides procedures for evaluating non-crop farm losses. Included in this category are damage to buildings, roads, machinery, livestock, stored grain, fertilizers, seed, ditches, and fences.

Methods of data collection are presented in Chapter VII. Topics include: appropriate level of detail, identification and delineation of damage reaches, determination of existing conditions, projection of most likely alternative future conditions with and without the project, collection of data, and identification of possible data sources.

Chapter VIII uses some examples to translate the concepts from previous chapters into benefit analysis. The final chapter, Chapter IX, discusses how agricultural flood control studies are documented in the form of reports, the types of reports, the appropriate level of detail for each, and documentation needed to support them.

CHAPTER II

OVERVIEW OF THE PLANNING AND EVALUATION PROCESS

The purpose of this chapter is to familiarize the reader with some of the basic planning considerations and processes that influence when and how a National Economic Development (NED) agricultural benefit evaluation is conducted. The chapter begins with a description of some basic planning considerations. Brief overviews of the planning process and the NED evaluation procedures for agriculture, as described in the P&G, are then presented. Also identified are some of the types of planning programs and studies for which the procedures described in this manual would be applicable. More detailed information on the Corps' planning process is available in the Planning Guidance Notebook.

PLANNING CONSIDERATIONS

FEDERAL OBJECTIVE

As stated in Appendix A to Engineer Regulation (ER) 1105-2-[illegible] (the Principles portion of P&G), the Federal objective of water and related land resources planning is to contribute to NED consistent with protecting the Nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. Contributions to NED are increases in the net value of the national output of goods and services, expressed in monetary units. They are the direct net benefits that accrue in the planning area and the rest of the Nation. Contributions to NED include increases in the net value of those goods and services that are marketed, as well as those that may not be marketed.

AGRICULTURAL NED BENEFITS

For agriculture, NED benefits are defined as the value of increases in the agricultural output of the Nation and the cost savings in maintaining a given level of output. The benefits include reductions in production costs and in associated costs; reduction in damage costs from floods, erosion, sedimentation, inadequate drainage, or inadequate water supply; the value of increased production of crops; and the economic efficieny of increasing the production of crops in the project area. More detailed descriptions of these benefits are included in Chapters III, V and VI; methods for calculating them are presented in Chapter VIII.

WILLINGNESS-TO-PAY

The general measurement standard for the value of all NED goods and services is defined in Appendix A to ER 1105-2-30 as the willingness of users to pay for each increment of output from a plan. Such a value would be obtained if the "seller" of the output were able to apply a variable unit price and charge each "buyer" an individual price to capture the full value of the output to the user.

For most publicly provided goods, an estimate of willingness-to-pay must be made since markets are not available to establish a price. The resultant change in net income or land value (described in more detail in Chapter VIII) is usually used as the estimate of willingness-to-pay for agricultural flood damage protection. The assumption is that the resultant increase in net income or land value is an acceptable proxy of the amount a rational individual would be willing to pay for the protection provided.

WITH- AND WITHOUT-PLAN CONDITIONS

Water resource development plans are formulated and evaluated for with- and without-plan conditions for the expected life of the plan. The purpose of making a distinction between "with" and "without" conditions is to isolate the changes that are expected to occur as a result of a plan, from those that would occur if the plan were not undertaken.

The without-plan condition is an assessment of the flood problem assuming the alternatives under investigation are not undertaken. If any other flood control works or other significant actions are imminent without the planned action, they must be considered part of, and help to define, the without-plan conditions. Impending actions might include funded flood control measures, development under construction, anticipated changes in cropping or other land use patterns, and any local regulations in effect.

Any changes in cropping patterns, yields or development that can be expected as a result of the plan should be considered in the delineation of with-plan conditions. Methods for collecting basic data and for determining with-and without-plan future conditions are described in more detail in Chapter VII.

PERIOD OF ANALYSIS

The period of analysis is defined in Appendix A to ER 1105-2-40, (the NED Procedures portion of P&G), as the time required for implementation of a plan plus the lesser of 1) the period of time over which any alternative plan would have significant beneficial or adverse effects; or, 2) a period not to exceed 100 years. The latter part of the period of analysis is commonly referred to as the "project life." Either 50 or 100 years is used as the project life in most Corps' studies. The same period of analysis is used for evaluating all alternative plans.

The base year is defined in Engineer Pamphlet (EP) 1105-2-45 as the first year the plan is expected to become operational. Forecasts of appropriate planning conditions such as population, land use, and storm water runoff are made for the base year and for selected years over the remainder of the project life. Projections are, generally, held constant beyond 50 years from the base year, because of the uncertainity of forecasting further into the future, and the minor effect they have on average annual benefits after discounting.

DISCOUNTING

Since water resource development benefits are usually distributed unevenly over time, discounting is used to derive net NED benefits in average annual benefit terms. To do this, the benefit stream is discounted to the base year using the applicable project discount rate. This cumulative present worth of benefit values is then amortized over the life of the project, again using the applicable project discount rate. Examples of using discounting in the determination of agricultural benefits are provided in Chapter VIII; a more detailed discussion of discounting procedures is provided in the NED Urban Flood Damage Manual. (Note: The phrase average annual equivalent is used in the P&G instead of average annual. The latter, as defined in EP 1105-2-45, will be used in this manual.)

As noted in ER 1105-2-40, Corps' headquarters will advise field elements of the interest rates to be used each fiscal year in plan formulation and evaluation. They are included in a Fiscal Year Reference Handbook distributed annually.

UPDATING

Project benefits should be updated as necessary and should be consistent with the level of intensity, accuracy and validity required, given the elapse of time since the project was last evaluated. Updating is an adjustment of project benefits from the last evaluation to account for changes in the processes, and the quantity and quality of inputs and outputs anticipated under with- and without-plan conditions. Whether or not benefits can be updated simply through the use of price indices or through more extensive reevaluation, will depend more on the magnitude of existing or anticipated changes in land use, technology, or the mixture of inputs and outputs, than on elapsed time.

When only prices are to be updated, indices for the update of agricultural crop benefits should be based on prices received and prices paid by farmers. Current normalized prices, (described in Chapter III), for these purposes are included in the Fiscal Year Reference Handbook. For updating other benefit categories, indicies with base period weights, such as Marshall and Swift, Engineering News-Record, and Consumer Price and Wholesale Indices may be used.

Price changes of various categories can often be measured to acceptable accuracy by using a composite of several existing indices. Most of the data used in developing these composite indices can be found in the Survey of Current Business. Since benefits accrue over a long period of time, changes in prices can normally be measured more accurately with national, rather than local data.

RISK AND UNCERTAINTY

Plans and their effects should be examined to determine the uncertainty inherent in the data or in various assumptions of future economic, demographic, social, attitudinal, environmental, and technological trends. A limited number of reasonable alternative forecasts should be considered that would, if realized, appreciably affect plan design.

The planner's primary role in addressing risk and uncertainty is to identify the areas of sensitivity and describe them clearly so that decisions can be made with knowledge of the degree of reliability of available information.

Situations of risk are defined as those in which the potential outcomes can be described in reasonably well-known probability distributions, such as the probability of particular flood events. Situations of uncertainty are defined as those in which potential outcomes cannot be described in objectively known probability distributions.

Risk and uncertainty arise from measurement errors and from the underlying variability of complex natural, social, and economic si'uations. Methods of addressing risk and uncertainty include:

1. Collecting more detailed data or using more refined sampling techniques.
2. Using more refined analytical techniques.
3. Increasing safety factors in design.
4. Selecting measures with better known performance characteristics.
5. Reducing irreversible or irretrievable commitments of resources.
6. Performing a sensitivity analysis of the estimated benefits and costs of alternative plans.

Reducing risk and uncertainty may involve increased costs or loss of benefits. The advantages and costs of reducing risk and uncertainty should be considered in the planning process.

OVERVIEW OF PLANNING PROCESS

As described in Appendix A to ER 1105-2-30, the planning process consists of a series of steps that identifies or responds to problems and opportunities associated with the Federal objective and specific state and local concerns and culminates in the selection of a recommended plan. The process consists of six major steps: 1) specification of problems and opportunities, 2) inventory and forecast of water and related land resource conditions, 3) formulation of alternative plans, 4) evaluation of effects, 5) comparison of alternative plans, and 6) plan selection. Each of these steps is described below.

STEP ONE: SPECIFICATION OF PROBLEMS AND OPPORTUNITIES

The desire to alleviate problems and realize opportunities should be specified for the planning area in terms of the Federal objective and specific state and local concerns. Problems and opportunities should be stated for both current and future conditions. Initial expressions of problems and opportunities may be modified during the planning process.

STEP TWO: INVENTORY AND FORECAST OF WATER AND RELATED LAND RESOURCE CONDITIONS

The potential for alleviating problems and realizing opportunities is determined during inventorying and forecasting. The inventory and forecast of resource conditions should be related to the problems and opportunities specifically identified during Step One. Collecting basic data and determining future conditions specifically for agricultural benefit analysis is described in more detail in Chapter VII.

STEP THREE: FORMULATION OF ALTERNATIVE PLANS

Alternative plans are to be formulated in a systematic manner to insure that all reasonable alternatives are evaluated. Usually, a number of alternative plans are identified early in the planning process and become more refined through additional development and through subsequent iterations. Additional alternative plans may be introduced at any time. Each alternative plan is to be formulated in consideration of four criteria: completeness, effectiveness, efficiency, and acceptability. Appropriate mitigation of adverse effects is to be an integral part of each plan.

STEP FOUR: EVALUATION OF EFFECTS

The evaluation of the effects of each alternative plan consists of assessment and appraisal. Assessment is the process of measuring or estimating the effects of an alternative plan. Assessment determines the difference between with-plan and without-plan conditions.

Appraisal is the process of assigning social values to the technical information gathered as part of the assessment process. Since technical data concerning benefits and costs for the NED evaluation are expressed in monetary units, no further weighting of effects is needed for the NED analysis. Weighting of effects for the Environmental Quality, Regional Economic Development, and Other Social Effects Accounts is required, but is beyond the scope of this manual. Examples of the evaluation of NED effects for agricultural benefit analysis are provided in Chapter VIII.

STEP FIVE: COMPARISON OF ALTERNATIVE PLANS

The comparison of plans focuses on the differences among the alternative plans as determined in the evaluation phase. With respect to the NED analysis, the focus is on maximizing net benefits. The most efficient use of resources for any one project comes when total benefits exceed total costs by the maximum amount. The maximum net benefit concept is, therefore, the best measure of investment in NED terms, because it contributes the highest dollar value of increased output to the economy. The plan that reasonably maximizes net NED efficiency benefits, consistent with the Federal objective, is designated as the NED Plan.

STEP SIX: PLAN SELECTION

As stated in ER 1105-2-10, the NED Plan is selected unless there is some overriding reason for selecting another plan based on Federal, state, local, or international concerns. Anticipated increased non-Federal project cost-sharing will require special consideration of acceptability and affordability. These considerations may be used as valid reasons for recommending less than the NED level of development.

OVERVIEW OF AGRICULTURAL NED EVALUATION PROCEDURES

EVALUATION PROCEDURE: CROPS

The procedure described in the P&G for evaluating benefits to crop production accruing from an alternative plan is summarized in Figure II-1. The procedure consists of nine steps, which are briefly described below:

Step 1: Identify land use and cropping patterns with and without a plan. This information is generally developed for segments of the study area with different characteristics. Factors to consider in delineating study segments are described in Chapters IV and VII. Data needs and methods for collecting data on land use and cropping patterns are also described in Chapter VII.

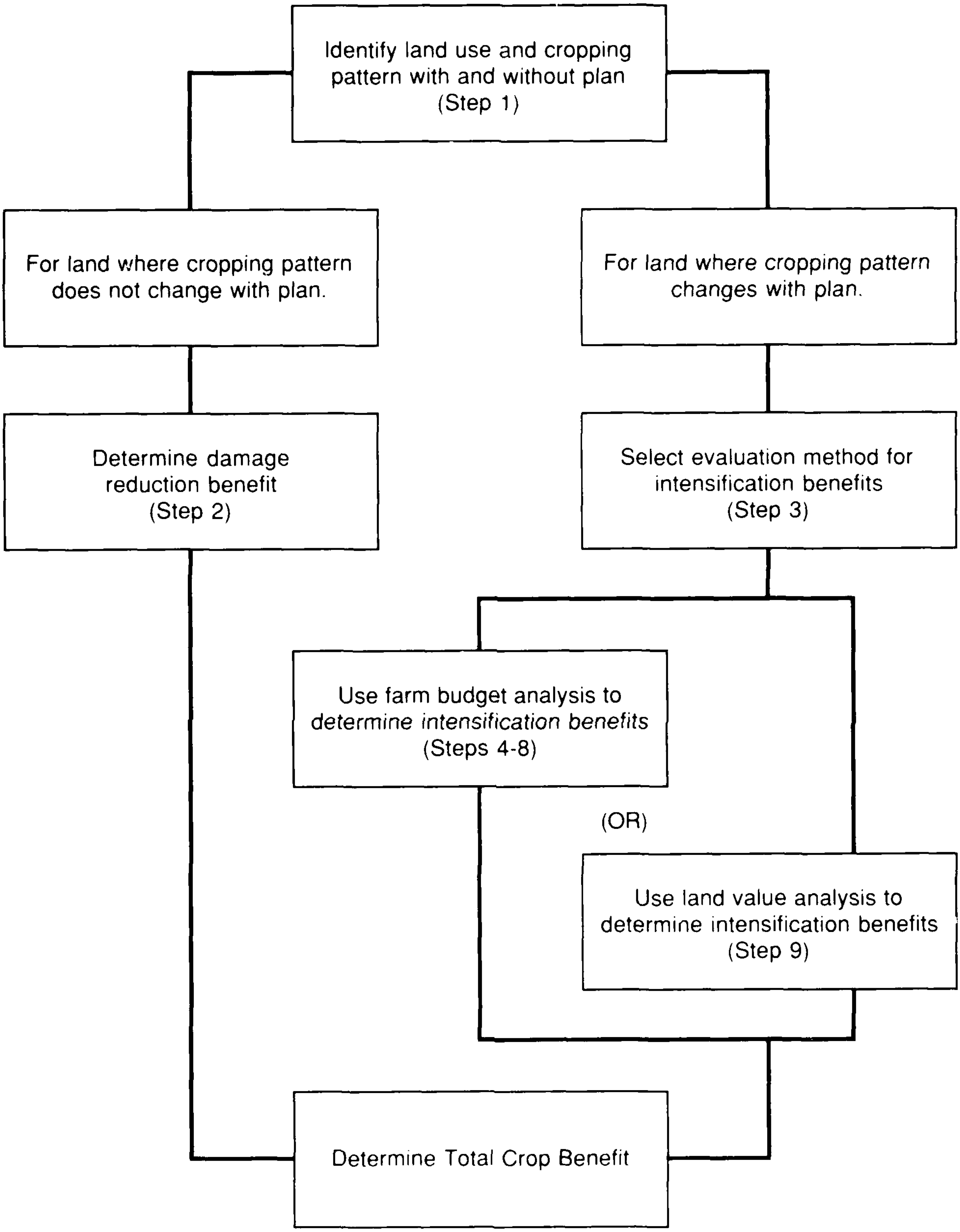

FIGURE II-1
FLOWCHART OF AGRICULTURAL BENEFIT EVALUATION PROCEDURE: CROPS

Step 2: Determine Damage Reduction Benefit. The damage reduction benefit is defined in the P&G as benefits that accrue on lands where there is no change in cropping patterns between the with- and without-plan conditions. The change in net income without and with a plan is the damage reduction benefit. Income increases may result from increased crop yields and decreased production costs. Farm budget analysis (discussed in Chapters V, VII amd VIII) is used to estimate damage reduction benefits. Predicting with- and without-plan yields and costs is described in Chapter VII.

Step 3: Select evaluation method for estimating intensification benefits. Intensification benefits are defined in the P&G as benefits that accrue on lands where there is a change in cropping pattern between the with- and without-plan condition. They are measured using either m budget analysis (Steps 4-8), or land value analysis (Step 9). When using the farm budget analysis approach, there is also a subcategory of intensification benefits, called efficiency benefits, that may need to be considered. These are described in Step 8.

Step 4: Determine whether other crops are to be treated as basic crops. Basic crops (i.e., rice, cotton, corn, soybeans, wheat, milo, barley, oats, hay, and pasture) are defined in the P&G as crops that are grown throughout the United States in quantities such that no water resources project would affect the price and thus cause transfers of crop production from one area to another. The production of basic crops is limited primarily by the availability of suitable land.

On a national basis, production of crops other than the ten basic crops is seldom limited by the availability of suitable land. Rather, production from increased acreage of crops other than basic crops in the project area would be offset by a decrease in their production elsewhere. When this is the case, the procedures for measuring efficiency benefits (Step 8) are used.

In some parts of the Nation, analysis of local conditions may indicate that the production of other crops is limited by the availability of suitable land. When this is the case, crops other than the ten basic crops may be treated as basic crops when measuring intensification benefits by farm budget analysis. A method for determining whether or not other crops can be treated as basic crops is described in Chapter VIII.

Step 5: Determine limit on acreage of other crops that may be treated as basic crops. When the production of other crops is found to be constrained by the availability of suitable land (Step 4), the maximum acreage of other crops that can be treated as basic crops for computing intensification benefits must be determined. The maximum acreage is based on the cropping patterns of optimal farming enterprises in the area. A method for determining the appropriate acreage limitations is described in Chapter VIII.

Step 6: Project net value of agricultural production with and without the plan. Using information from forecasted changes in cropping patterns and yields and farm budget analysis, the net value of agricultural production is estimated under with- and without-plan conditions. An example of the computational process for estimating net income under with- and without-plan conditions is provided in Chapter VIII.

Step 7: Compute intensification benefits for acreages of basic crops and other crops to be treated as basic crops. For each alternative plan considered, the intensification benefit is computed as the change in net income under the with- and without-plan condition. These intensification benefits are expressed in average annual terms, based on the applicable discount rate and appropriate discounting procedures. Example calculations of intensification benefits are provided in Chapter VIII.

Step 8: Determine efficiency benefits. Efficiency benefits accrue for other crops not treated as basic crops, because they can be produced more efficiently on lands affected by the water resources development plan than on other lands in the area. There are three components to efficiency benefits: 1) the difference between the cost of producing the crops in the project area and the cost of producing them elsewhere; 2) any loss of net income from crops or other activities displaced in the project area by the increased production of other crops; and, 3) the net income that would accrue from production of an appropriate mix of basic crops on those other lands from which the production of other crops is transferred. Efficiency benefits are also expressed in average annual terms. An example of the computation of efficiency benefits is provided in Chapter VIII.

Step 9: Land Value Analysis. An alternative to the use of farm budget analysis (Steps 4-8) in the computation of intensification benefits is land value analysis. It is based on the comparison of market appraisals of project lands with market appraisals of comparable lands outside the project area. Market values, not capitalized income values, are to be used. Use of this technique requires input from qualified and experienced land appraisers. A description of the land value analysis approach is provided in Chapter VIII.

EVALUATION PROCEDURE: NON-CROP AGRICULTURAL DAMAGE

Although generally not as important as crops, non-crop losses can acount for a significant portion of benefits for some agricultural flood damage reduction projects. Briefly described below are the general non-crop benefit categories identified in the P&G. A more detailed description of the types of non-crop damages that should be considered, including methods for determining damage susceptibility for equipment and other capital improvements, is provided in Chapter VI. Methods for collecting appropriate data are described in Chapter VII, and methods for computing non-crop benefits are described in Chapter VIII.

Damage reduction benefits for other agricultural properties. The term "other agricultural properties" includes physical improvements such as homesteads, barns, fences, and equipment associated with various farm enterprises and the agricultural community. Benefits to such properties are measured as the reduction in damages in the future with the plan compared to those without the plan. Benefits can accrue through alterations in water conditions or in altering the susceptibility of the property to damage (e.g., flood-proofing).

Damage reduction benefits for associated agricultural enterprises. Associated agricultural enterprises are economic activities that may be affected by changed water supply or water management conditions. An example of this type of damage is a delay in spring planting on floodfree lands because of flooding of access roads. Benefits are measured as changes in net income under with- and without-plan conditions.

Off-site sediment reduction benefits. Off-site sediment damages may include physical costs of removing sediments from such facilities as roads, bridges, ditches, and drainage systems, as well as additional costs for water treatment. Increased off-site costs for land treatment from scouring and/or deposition should also be considered.

PLANNING STUDIES

The P&G established standards and procedures for use by Federal agencies in formulating and evaluating alternative plans for water and related land resources implementation studies. Implementation studies are defined in the P&G as pre- or post-authorization studies undertaken by a Federal agency. These are, generally, the types of studies conducted by the Corps under its Feasibility and Preconstruction Planning and Engineering Studies Planning Program, described in Chapter 1 of ER 1105-2-10.

In addition to implementation studies, the concepts and procedures described in this manual are appropriate for evaluating NED agricultural benefits for initial appraisal, reconnaissance, and detailed project studies under the Corps Continuing Authorities Program, described in Chapter 4 of ER 1105-2-10. The concepts and procedures may also be appropriate in the conduct of other special studies concerned with identifying or evaluating potential agricultural flood damages or benefits under the Corps' Changes to Completed Projects, Project Deauthorization Review, Flood Plain Management Services, and Planning Assistance to States Planning Programs, described in ER 1105-2-10.

The process is the same for all of these studies; only the amount of detail changes, based on study objectives and available planning resources. Some of the specific studies and reports for which the concepts and procedures described in this manual would most typically be used are identified below.

FEASIBILITY AND PRECONSTRUCTION PLANNING AND ENGINEERING STUDIES PLANNING PROGRAM

Feasibility Studies. The objective of feasibility studies is the timely and economical completion of quality reports that recommend solutions to water resources problems. A two phase planning process has been established for feasibility studies, which provides a mechanism to accommodate significant non-Federal participation in the planning process.

The reconnaissance (first) phase provides a preliminary indication of the potential of the study to yield solutions which could be recommended to the Congress as Federal projects. The reconnaissance phase is expected to: 1) define problems and opportunities, and identify potential solutions; 2) determine whether or not planning should proceed further, into a feasibility phase, based on a preliminary appraisal of the Federal interest, costs, benefits and environmental impacts of the identified potential solutions; 3) estimate costs for the feasibility phase; and, 4) assess the level of interest and support of local interests in the identified potential solutions. The results of the reconnaissance phase provide the basis for decision-making to evaluate the merits of continuing the study and allocating feasibility (second) phase funds.

The feasibility phase is conducted under current Federal guidelines and statutes and results in a feasibility report with a recommendation to Congress. Reports prepared during this phase, for which the concepts and procedures described in this manual might typically be applied, include the following:

1. Survey Report. This report is prepared in partial or full response to a Congressional study authority.

2. Legislative Phase I General Design Memorandum. This report is prepared in response to specific Congressional authorization for the Phase I stage of advance engineering and design.

3. Section 216 Report. This is a report to Congress recommending changes to a completed project. These reports are authorized by Section 216 of the River and Harbor and Flood Control Act of 1970.

Preconstruction Planning and Engineering Studies. The objective of preconstruction planning and engineering studies is the accomplishment of all necessary studies, as rapidly as possible, to ready the project for construction. Planning activities, for which the concepts and procedures described in this manual might typically be applied during the conduct of these engineering studies, include the following:

1. General or Limited Reevaluation. The study effort is to affirm or reformulate a plan or portions thereof, or to modify a plan, under current planning criteria. This activity includes economic and environmental reevaluation which may be required separately at different stages of project development.

2. Economic Reevaluation. The study effort provides a reevaluation of only project economics, in whole or in part, under current policies and criteria.

CONTINUING AUTHORITIES PLANNING PROGRAM

The Continuing Authorities Program, is a group of seven legislative authorities under which the Secretary of the Army, acting through the Chief of Engineers, is authorized to plan, design and construct certain types of water resources improvements without specific Congressional authorization. General requirements of the Program are described in Chapters 4 of ER 1105-2-10 and EP 1105-2-15.

Projects considered under this Program are usually much smaller than those considered in implementation studies. Planning resources available to conduct studies are also very limited, which means the level of detail tends to be less than for comparable implementation studies. Concepts and procedures described in this manual are, however, still appropriate for the Continuing Authorities studies described below. The two phase planning approach, described for the Feasibility and Preconstruction Planning and Engineering Studies Program, is also applicable for these studies.

Initial Appraisal. Generally, an Initial Appraisal concentrates on the identification of problems, opportunities and potential solutions. It ascertains if a potential solution exists that is economically, environmentally, and engineeringly viable, and whether further studies are warranted. To support a recommendation for further study the appraisal must determine that local interests are aware of and capable of fulfilling further study and implementation responsibilities. The appraisal results in an Appraisal Report. Costs for the appraisal are not to exceed $7,500 unless an exception has been granted.

Reconnaissance Study. The purpose of a reconnaissance investigation for a Continuing Authority Study is to determine whether a Detailed Project Study is warranted. The criteria for making that determination should be based on the likelihood of having the study result in a recommendation for Federal action. The Reconaissance Study will include a preliminary appraisal of costs, benefits, and environmental impacts. It should normally be completed in a period of 6 to 12 months.

Detailed Project Study (DPS). The DPS should complete the plan formulation process for Continuing Authority Projects. This includes the selection of a plan, generally in accordance with guidance for feasibility studies, or as otherwise provided in planning regulations which include specific guidance for continuing authorities.

CHAPTER III

BASIC CONCEPT, PRINCIPLES AND DEFINITIONS

The purpose of this chapter is to discuss the basic concept of agricultural damage and some of the principles that must be considered during the course of an agricultural damage analysis. To help clarify this discussion, a simple scenario is introduced which describes a flood problem in an agricultural setting. Examples in the scenario are intended to help illustrate the application of the principles subsequently described. Chapter VIII builds on this scenario as it describes the analytical processes and methods used to estimate agricultural flood damage. This chapter concludes with a list of terms and definitions associated with agricultural damage analysis.

SCENARIO

The Rising River has a history of overtopping its banks and flooding adjacent farmland. Records of flooding go back as far as the mid-1800s. Crops presently grown in the floodplain consist primarily of corn, wheat, and soybeans. When flooded, crop yields are reduced by varying degrees, depending on the timing and characteristics of the flood event. Larger floods will also damage roads and other agricultural property. Other agricultural property that has been damaged in previous floods includes various farm structures, miscellaneous farm machinery and equipment, stored grain and feed, fences and livestock. Damage has also occurred in the form of sediment deposition on fields and in drainage ditches and of erosion of topsoil.

Over the last 15-20 years, the flood problem appears to have gotten worse. Land adjacent to the Rising River has been getting flooded often, once every 3 or 4 years. This land originally was in woodland and shrubland. However, during the drier portions of the river's hydrologic history when floods were less frequent, farmers converted some of the acreage to cropland and were able to produce profitably on it. Lately, though, this land has become particularly vulnerable to even small flooding events, and many farmers are no longer planting crops on it.

The most recent flood occurred in June 1984 and caused considerable crop damage and hardship on the affected farmers. Approximately 1100 acres of cropland were flooded by a peak flow of 4600 cubic feet per second (cfs). This corresponds to a 25-year flood event. The growing flood problem has prompted the Rising River Watershed District to approach the Corps of Engineers in an effort to obtain some means of flood protection.

Hydrologic records of the Rising River indicate that flooding, especially the larger flood events, is associated mostly with spring snowmelt and runoff. These floods don't damage a crop directly, but they do delay planting and, as a result, final yields are lower. In some years planting has even been delayed to the point where farmers could no longer plant the optimal crops and had to substitute alternatives with shorter growing seasons, further lowering income producing potential. Farmers try to compensate from planting delays by seeding at a higher rate and applying more fertilizer. This, however, results in higher production costs, and even if the final yields approach the farmer's target yields, net income is lower.

Floods also occur in the summer. Summer floods occur less frequently but are much more damaging because the investment in the production of the crop is greater and the impact on the crop's yield potential is more harmful. The 1984 flood was devastating, not necessarily because of its size or the number of acres flooded, but because of its timing in the production cycle. The crops were well into their growth stage and replanting was impossible. Occasionally, fall and winter floods also occur. Production and harvest are normally completed by then, so income loss is less likely.

BASIC CONCEPT AND PRINCIPLES

As described in the above scenario, the damage to agricultural enterprises that is caused by flooding includes lower physical output and/or higher production costs. This discussion concentrates on the impacts of flooding on crop production, but many of the principles also apply to livestock, dairy, poultry, and other producing operations.

Flood damage to crops, whether caused by the direct physical contact of floodwater on the crop or by other related factors, such as delayed planting, erosion, sedimentation, or weed infestation, will always translate into lower net income for the affected producer. This is a loss to the Nation as well, because it cannot be recovered from the other sectors of the economy.

Under normal conditions, a farmer will perform the necessary operations (e.g., tillage, planting, chemical application, cultivation, and harvesting) and will apply a given level of inputs (e.g., seed, fertilizer, pesticides, and capital) to achieve a desired level of production (usually expressed as bushels, tons or hundredweight per acre). Any external interference, such as drought, hail or flooding, upon this ideal production flow, will result in lower yields and lower gross income, given the same production schedule, or in higher production costs, given the same target yields. In either case, the net income produced from that land, and consequently the agricultural output for the Nation, is reduced by the amount of damage. In most cases, both losses in yield and increases in costs will occur, thus squeezing the net income from both sides. In fact, net income can easily be negative for the affected acres.

In addition to crops, flooding damages other agricultural property as well. This includes buildings, machinery, livestock, stored grain and feed, fences, and other improvements and equipment associated with the agricultrual enterprise. The principles and procedures involved with the evaluation of non-crop flood damage are discussed in greater detail in Chapter VI.

SPECIAL CONSIDERATIONS

Many factors must be considered when evaluating flood damage to cropland. Special considerations that are presented herein include seasonality of flooding, frequency of flooding and its effect on land use, mean daily versus instantaneous peak discharges, separation of flood events, crop prices, and the potential for damage in years following a flood year.

Seasonality. Among the most important considerations is the seasonality of the flood event. For urban areas, damages from a particular flood event would generally be similar regardless of when the flood occurs during the year.

Seasonal variations can occur if, for instance, commercial/industrial inventories vary by season, or if freezing occurs subsequent to flooding resulting in additional structural damage. But, for the most part, the damage potential remains fairly stable throughout the year.

Floods in agricultural areas are different. For example, if the optimal planting date for corn is April 30, and if a parcel of land to be planted with corn floods and dries out before that date, little, if any, damage is likely to occur. In contrast, the same flood event in June will inundate an established crop and likely cause much more damage. The typical relationship of damage along a timeline would show a generally upwardly sloping curve, reflecting the fact that damages will increase as flood dates move from earlier to later in the production cycle. Once harvest begins, the damage curve would begin to decline as the harvested crop is removed from the threat of flood damage. This general relationship is graphically depicted in Figure III-1. (A detailed discussion of the development of such crop damage functions is provided in Chapter V and examples of their use in damage analysis in Chapter VIII.)

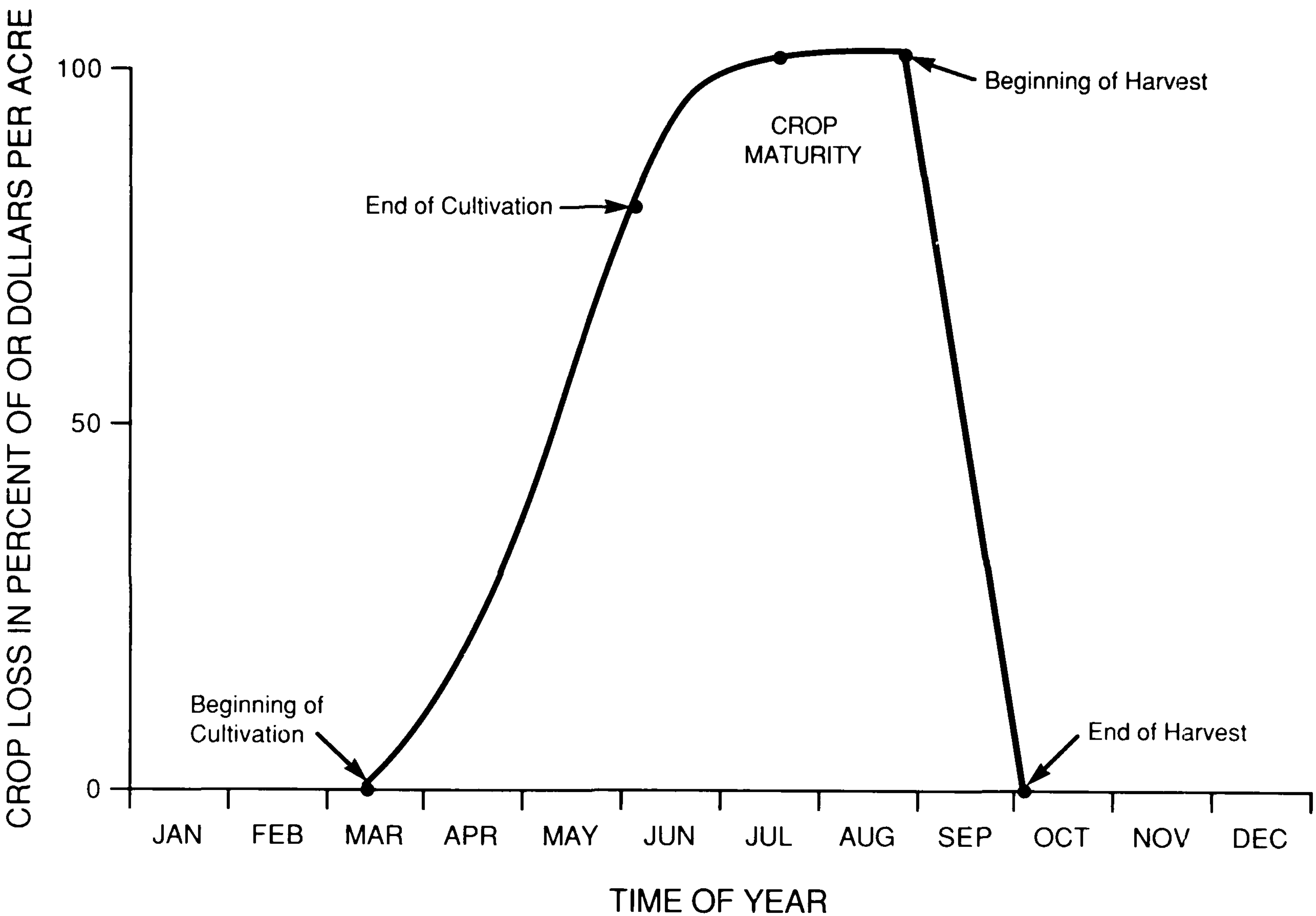

FIGURE III-1 EXAMPLE CROP LOSS FUNCTION

As a related point, the stage where plant growth happens to be during a flood may also influence the extent of damage. Some crops tend to be more sensitive to flooding in the earlier part of their growth stage than in their later stages when they are hardier and more established. A corn crop, for example, might be more tolerant of flooding when it is nearing maturity than when it is just emerging from the ground. This would suggest that there is some point during the growing season (and before the beginning of harvest) beyond which flood damages can actually decrease as the crop approaches maturity. The seasonal crop damage curve would slope downwards to reflect this situation. The final form of any particular seasonal crop damage curve will be dependent, not only on the crop being considered, but also on the local cultural, climatic and hydrologic conditions of the study area.

Frequency. Another important consideration during an agricultural damage evaluation is the frequency of flooding. The frequency of flooding impacts on flood damage and benefits in two ways. Most obvious is that the more frequent the flooding the more often flood damage is incurred. However, the frequency of flooding also has a direct impact on the land use or cropping pattern of a floodplain and, therefore, potential net income.

Land that is frequently flooded will often be put to a use having a lower damage potential, a use whose product is, generally, valued less and is more flood-tolerant, such as pasture or hayland. When flooded, these types of land use require less effort and resources from the producer to regain full productivity. By using this land for such crops, however, the producer must give up the opportunity to grow crops that could provide a greater income. If a flood control project can reduce the frequency of flooding on a given parcel of land (for example, from once in three years to once in ten) a farmer may be able to plant higher-valued crops with reasonable assurance that he will get a yield from the land. In this case, the land is said to be used more "intensely" (intensification benefit). The net income received from the land is higher, resulting in subsequently higher land values as well. This is considered a benefit to the national economy.

Duration. A third consideration that must be addressed when evaluating agricultural flood damage is flood duration. Damages in urban areas are related more to peak discharge or elevation, regardless of how long the flood may be at that point. Crops, however, may tolerate at least short periods of inundation with minimal impact on final yields (other factors such as the velocity and the debris and sediment load may override duration as agents causing flood damage in some areas). Above a certain point, though, crop losses increase sharply with relatively smaller increases in duration. Because of the duration factor, mean daily discharges, rather than instantaneous peak discharges, are used to estimate the damageable areal extent of a particular flood event.

Instantaneous peak discharge, on any day of a flood event, is the largest discharge experienced on that day. Mean daily discharge is the average flow required to equal the volume of water flowing past a point on that particular day. Instantaneous peak discharge will be greater than mean daily discharge and subsequently will flood a greater number of acres. The additional acres flooded above those flooded by the mean daily discharge are inundated for such a short duration, however, they will generally experience very little, if any, flood damage.

Again, crop damage may be more dependent for some study areas on factors other than duration, in which case, the appropriateness of using mean daily discharges may be questioned. Instantaneous peak flow measurements are more appropriate for floodplains prone to flash floods where the differences between instantaneous and mean daily flows are greater and where damages are more dependent on velocity than duration.

For any given flood event, different portions of the flooded area will be inundated for varying lengths of time, depending on elevation. As floodwaters rise and recede, lands at lower elevations are flooded longer than those at higher elevations. Consequently, damage to similar crops will usually be greater at the lower elevations. To account for this in the damage analysis, it is useful to partition (stratify) the floodplain into elevation (i.e., duration) zones in order to more accurately estimate the damage caused by a flood. This concept is illustrated in Figure III-2. Additional discussion of elevation zones is provided in Chapters IV and VII, and an example of their use in Chapter VIII.

<u>Separation of flood events.</u> A fourth consideration concerns the separation of flood events. This pertains to the interval that must occur from one flood to the next to identify them as separate and distinct damage events. For example, suppose that 100 acres of cropland are flooded and the water recedes. Five days later the water rises to flood the same 100 acres. Within

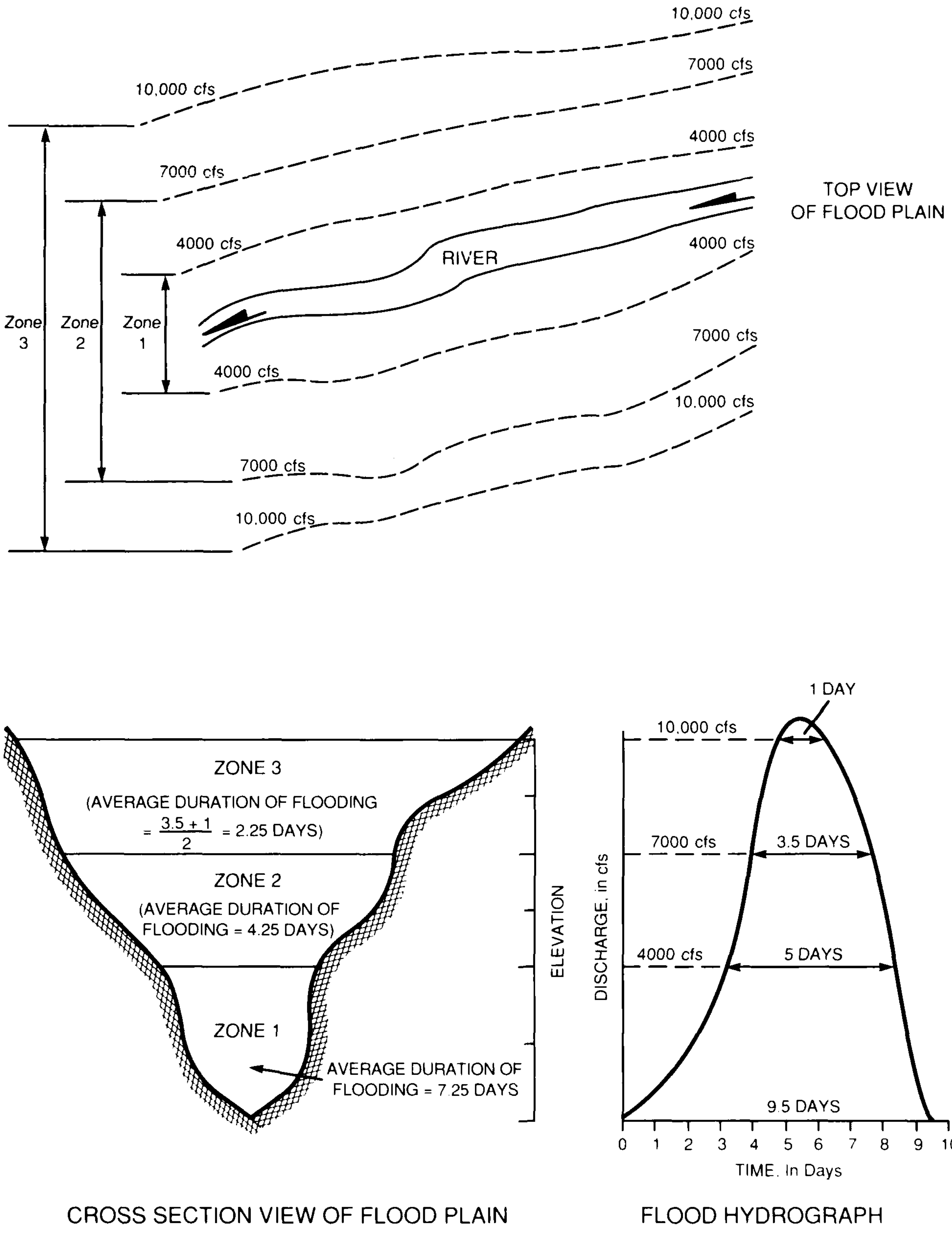

FIGURE III-2 DURATION OF FLOODING BY ZONES

the five-day interval, the land remains wet and the farmer is unable to begin the recovery process. No additional investment is made, and the second flood causes no additional damage other than to delay production further, as if the two peaks were actually one larger event.

Now assume that the second peak comes one month after the first. Within the interval, the land may have time to dry out and the farmer may make an effort to recover from the first flood. When the second flood occurs, the farmer has made additional investment towards crop production (e.g., replanted) and will suffer additional damages above those caused by the first and separate event. To account for this in the damage analysis, the length of time it takes for land to dry out and for the production process to be resumed must be determined. This information is needed for hydrologists to identify separate events when developing frequency-discharge relationships that account for the possibility of more than one flood event occurring in the same year. These are referred to as partial duration, versus annual peak frequency curves. A more detailed discussion of the two types of frequency relationships used in flood damage analysis is provided in Chapter IV.

Price fluctuations. Crop prices pose another problem for analysts, primarily because of their volatility. The nature of water resources planning requires that the long-term effects of water projects be considered. Prices used for evaluation should reflect the real exchange value expected to prevail over the period of analysis. For this purpose, relative price relationships of inputs and outputs prevailing during, or immediately before, the planning period generally represent the real price relationships expected over the project life.

Because crop prices are so volatile, normalized prices, derived by the Department of Agriculture, are used for agricultural damage and benefit evaluation. Normalized prices were developed to minimize the short run variability in agricultural market prices caused by such factors as abnormal weather patterns and sudden demand changes. An example of the moderating influence normalization has on crop prices is illustrated in Figure III-3. Historic season average prices (SAP) and current normalized prices (CNP) for Minnesota soybeans from 1974 to 1984 are compared in Figure III-3. Current normalized prices exhibit less fluctuation. The average year to year price difference is 54.5 cents for the CNP and 124.5 cents for the SAP. Current normalized prices for principal agricultural commodities are published and distributed annually by the Corps in its Fiscal Year Reference Handbook.[1]

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[1]At the time of publication of this manual, current normalized prices based on market conditions with government programs for all commodities are to be used to (1) establish the "with-" and "without-project" conditions (e.g., land use and cropping patterns) and (2) a farmer's "ability to pay", where required by current law, while normalized prices free of government programs are to be used for appropriate commodities in the benefit evaluation (Draft EC 1105-2-178). Normalized prices, both with- and without-government programs were initially provided in the fiscal year 1987 Reference Handbook dated 24 July 1987 (EC 1105-2-177).

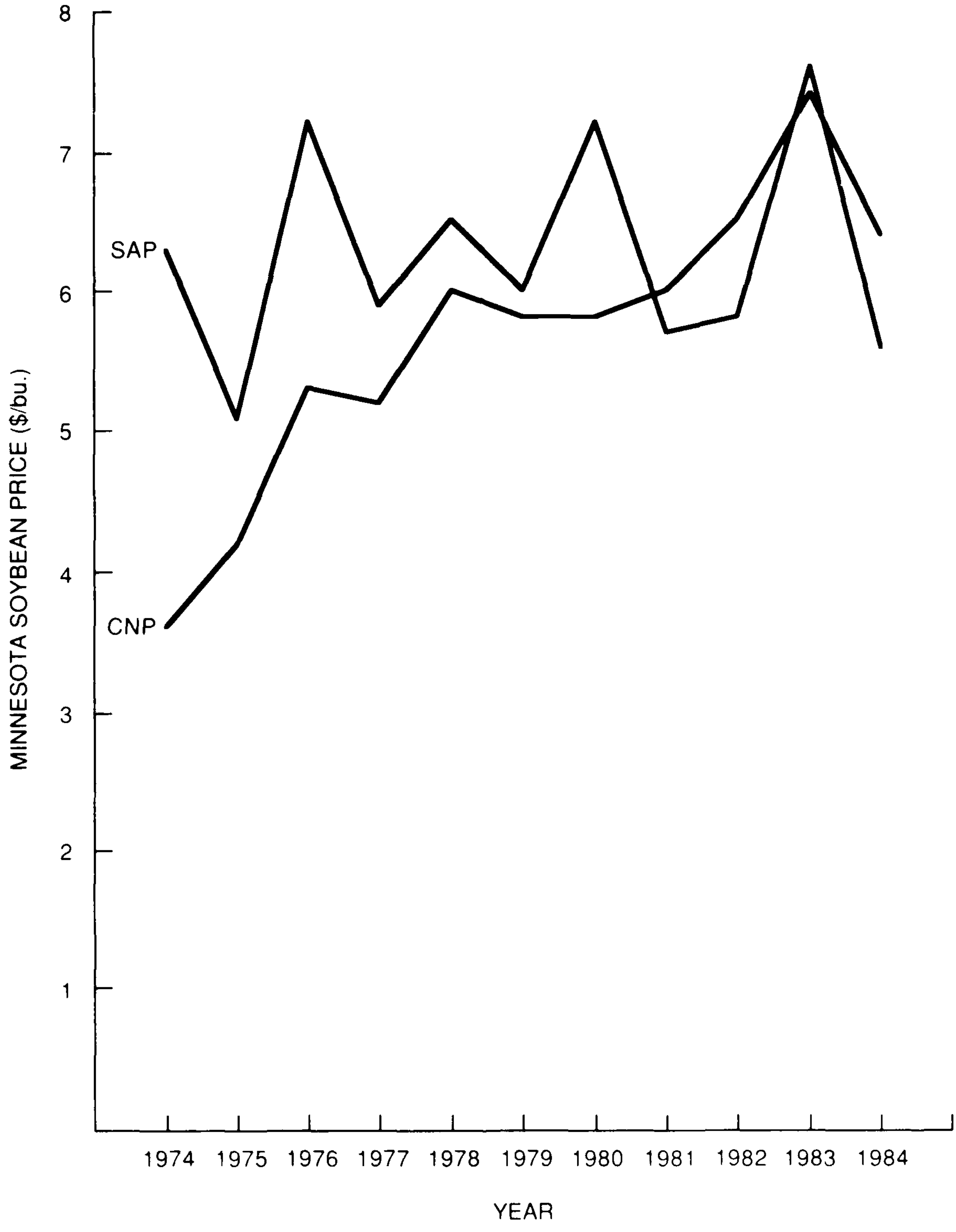


FIGURE III-3
COMPARISON OF SEASON AVERAGE PRICE (SAP) AND CURRENT NORMALIZED PRICE (CNP)

Persistent flood impacts. The final consideration to be discussed relates to economic impacts that may persist in years following a particular flood event. For example, erosion of topsoil from flooding may be so severe that yields in subsequent years may be reduced, as well as in the year of the actual flood event. A farmer may try to counter losses in fertility by adding more fertilizer to boost yields, but this is an additional cost, resulting in subsequent reduction of net income. Sedimentation can have similar, long range impacts, although in some cases they can be positive, rather than negative. These losses (or gains) may be less obvious than the devastating effects of direct flood damage and may be more difficult to estimate, but they are nonetheless real and should be considered where appropriate.

DEFINITIONS

Some of the important terms and concepts often used in agricultural flood damage analysis are defined below:

BASIC CROPS

Basic crops are the ten crops (i.e., rice, cotton, corn, soybeans, wheat, milo, barley, oats, hay, and pasture) that are described in the P&G as being grown throughout the U.S. in sufficient quantities such that no single water resources project would affect the market price and thus cause transfers of crop production from one area to another. The production of basic crops is limited, primarily, by the availability of suitable land. (Chapter VIII)

CROP BUDGET

A crop budget is a systematic schedule of all costs (and sometimes revenues) associated with the output of a unit of production. An example is an itemization of all costs and revenues related to the production of an acre of a given crop. (Chapters V, VII and VIII)

CROPPING PATTERN

A cropping pattern describes the distribution of crops grown (or projected to be grown) in a particular area. It is commonly expressed in percentages of land use that the various crops occupy. (Chapters VII and VIII)

DAMAGE REACH

Damage reaches are used to define boundaries for data aggregation, analysis, and reporting. Damage reach delineation requires coordination between economists, hydrologic engineers, and hydraulic engineers. (Chapters IV and VII).

DAMAGE REACH INDEX LOCATION

The index location is a specified reference point within a damage reach where crop damage is aggregated and rating curves and event hydrographs are developed. (Chapters IV and VII).

DAMAGE REDUCTION BENEFITS

Damage reduction is one of the NED benefit categories identified in the P&G. It is measured as the difference in net income between with-and without-project conditions when no change occurs in cropping patterns. (Chapter VIII).

EFFICIENCY BENEFITS

Efficiency benefits are identified in the P&G as a subcategory of intensification benefits. Efficiency benefits are measured as savings in production costs resulting from the production of crops on project lands versus other land within the Water Resources Council assessment area. (Chapter VIII)

ENTERPRISE

An enterprise is a unit of economic activity organized for the purpose of producing a good for future sale and profit. Examples include crop-producing and livestock-producing enterprises. (Chapters VII and VIII).

FARM BUDGET ANALYSIS

Farm budget analysis is a method of measuring changes in net incomes by comparing crop budgets under with- and without-project conditions. (Chapters VII and VIII).

FIXED COSTS

Fixed costs are those that a producer will incur, in the short run, regardless of the level of production. Included are items such as depreciation, interest, repairs, taxes, and insurance. (Chapter V).

FLOW-FREQUENCY RELATIONSHIP

This defines the relationship between exceedance frequency and flow at a location. It is the basic function describing the probability nature of stream flow and is commonly determined from either statistical analysis of gaged flow data or through watershed model calculations. (Chapters IV and VIII)

FREQUENCY HYDROGRAPH

A frequency hydrograph is defined as a flow hydrograph for a specified exceedance frequency in which the peak, volume and all durations are statistically consistent. It represents the typical flood response of a watershed and describes the relationship between time and discharge for a particular event, (e.g., the 25 percent chance event). (Chapters IV and VIII).

GROSS INCOME

Gross income is the product of total output times price per unit of output. For example, the gross income for an acre of wheat that yields 45 bushels per acre at $3.50 per bushel equals $157.50 (Chapters V, VII and VIII)

INTENSIFICATION BENEFITS

Intensification is one of the NED benefit categories identified in the P&G. It accrues on lands where there is a change in cropping patterns between the with- and without-project condition and is measured using either farm budget or land value analysis. There is also a subcategory of intensification benefits called efficiency benefits. (Chapter VIII)

LAND VALUE ANALYSIS

Land value analysis is the comparison of the values of benefitted lands with and without the project. Theoretically, land values reflect the expected net income that can be derived from the land. Therefore, the difference in market value between two parcels of land that are identical, except for the provision of improved water conditions on one reflects the present value of the additional net income that could be derived from the improvement. (Chapters VII and VIII).

NET INCOME

Net income is the gross income less the costs (either variable or variable and fixed costs depending on the application). Land values and net incomes are related in that, theoretically, the value of a parcel of land is equal to the present value of the stream of expected future net income to be derived from the land. (Chapter VIII).

OTHER CROPS

Other crops are defined in the P&G as any crops other than the ten defined as basic crops. The production of other crops is seldom limited by the availabiltiy of suitable land. Rather, production is generally limited by other elements such as market demand, risk aversion, and other supply factors. (Chapter VIII).

PRODUCTION CYCLE

The production cycle is the period of time during which all operations required to produce a unit of output are performed. The production cycle for corn, for instance, may start in the fall with tillage or fertilizer applications and run until harvest the following year. In areas where double cropping is possible, there may be two production cycles per year. (Chapters IV, V and VIII).

REPLANT

Replanting is the situation that arises when the original crop has either been destroyed by a flood or its planting has been delayed beyond the optimal planting date resulting in reduced yields. If floods occur too late for replanting with the original crop, alternative crops may be substituted that normally will generate lower net income for the producer. (Chapters V, VII and VIII).

SEASONALITY

As it relates to the evaluation of agricultural damages, seasonality refers to the timing of flood events coincident with the stage of crop production. Flood damage will vary considerably, depending on when, during the production cycle, a flood occurs. (Chapters IV, V, VII and VIII).

SEPARATION OF FLOOD EVENTS

The separation of flood events is the determination of the length of time required to identify consecutive flood peaks as separate and distinct damaging flood events. In urban areas, the recurrence interval may be the length of time needed for property owners to recover from the flood, make necessary repairs, and resume thir normal living patterns. In agricultural areas, it is the length of time required for cropland to dry out and for farmers to resume production activity. (Chapters IV, V and VII).

STAGE-DAMAGE RELATIONSHIP

This is the economic counterpart to the stage-flow function and represents the damage which will occur for various river stages. Usually the damage represents an aggregate of the damage which could occur some distance upstream and downstream from the index location. (Chapter VIII).

STAGE-FLOW RELATIONSHIP

This is a basic hydraulic function that shows the relationship between flow rate and stage (elevation) for a specific location. It is frequently referred to as a "rating curve" and is normally derived from water surface profile computations. (Chapters IV and VIII).

VARIABLE COSTS

Variable costs, sometimes called operating costs, are those costs that vary directly with the level of production. For a crop-producing operation, variable costs include the costs for such items as seed, fertilizer, pesticide, fuel and custom work. (Chapters V, VII and VIII).

CHAPTER IV

CROP FLOOD DAMAGE ANALYSIS PROCESS

The purpose of this chapter is to present an integrated overview of the process needed to perform agricultural crop flood damage analysis. Included are descriptions of alternative analytical approaches, needed data and analysis coordination for these alternatives, and guidelines for performing elements of the calculations. Other chapters are identified where more detailed descriptions of the concepts and issues presented in this chapter can be found. In addition, Chapter VI contains a discussion of methods for analyzing non-crop agricultural damage, while Chapter VIII provides more detailed examples of the analyses of both crop and non-crop damage.

OVERVIEW

The estimation of damage to agricultural crops caused by floods is needed to determine the NED benefits that may accrue to flood damage mitigation projects. The goal is to determine the expected value of annual damage for without-project conditions and the consequent damage reduction benefits for alternative mitigation plans of interest.

In a simple conceptual way, the damage estimation goal is as presented in Figure IV-1. For illustrative purposes, the flood threat over a planning horizon may be represented by the time history of flood elevation, (often referred to as the stage), shown as the upper time trace in Figure IV-1. This time trace is referred to as an elevation or stage hydrograph. Transforming this time trace of flood elevations to a time trace of flood damage, and subsequently computing the average (or better termed the "expected") value for the record period (using either a period of record or frequency analysis approach) is the analytical goal. Performing the analysis for existing and expected future conditions without proposed mitigation plans yields the "without" condition flood damage, and repeating the analysis for a proposed flood loss mitigation plan yields the "with" condition flood damage. The difference between the without and with conditions is the flood damage reduction benefit -- normally expressed as the expected annual benefit.

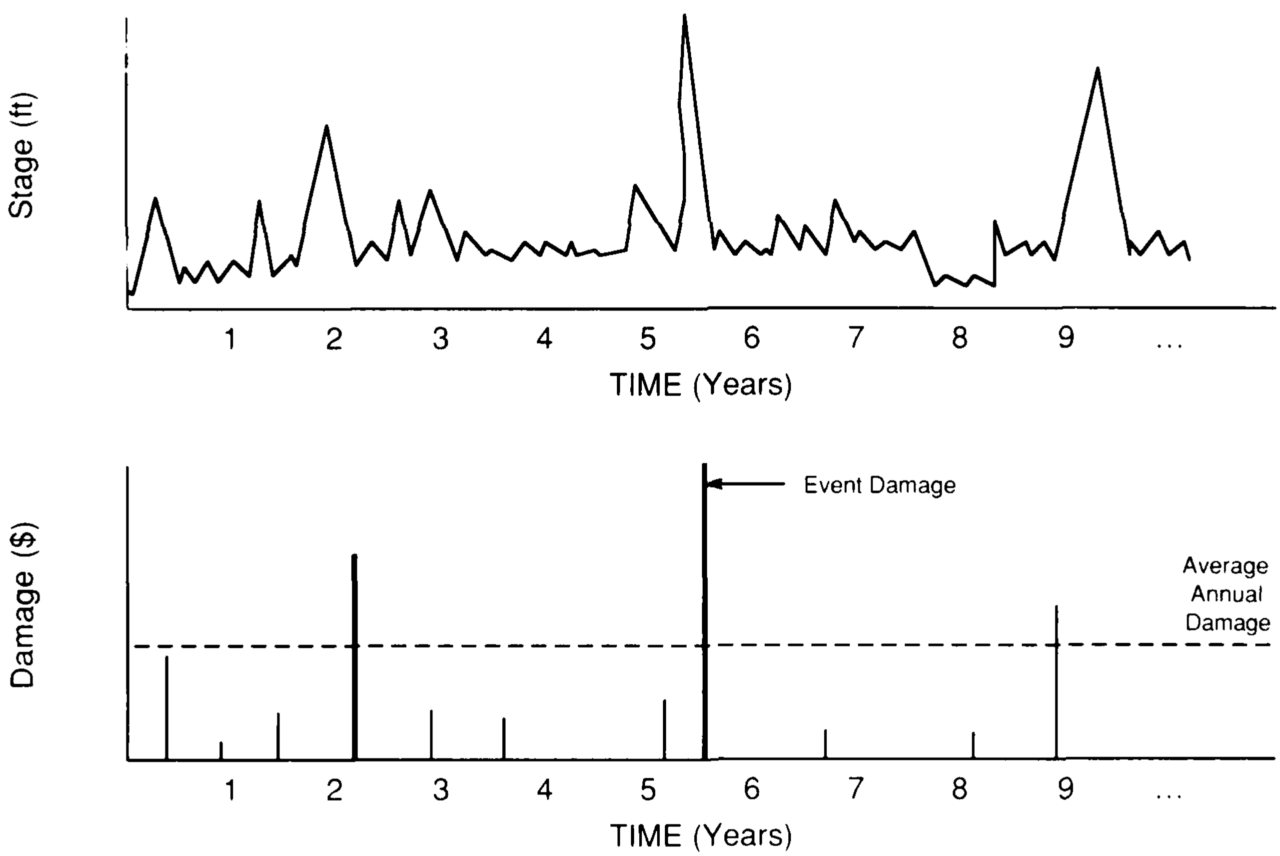


FIGURE IV-1 GENERAL CONCEPT - DAMAGE ESTIMATION GOAL

Two alternative computation strategies are commonly used to estimate the annual damage to crops. One strategy is termed the "continuous record" method. It is designed to mimic the conceptual picture presented in Figure IV-1, by computing the crop damage for a continuous record elevation-hydrograph. The strategy consists of developing and applying computational methods that permit accurately determining the crop damage consequences (under existing as well as future with- and without-project conditions) from an historic record of flooding. Another strategy, often termed the "frequency" method, more closely resembles the commonly used approach in performing urban flood damage analysis. Flood damage is computed (again for existing as well as future with- and without-project conditions) for a series of synthetic frequency flood events and the result is weighted by the exceedance probability of the events to develop the expected annual value.

STRATEGY SUMMARY

A step by step strategy for determining the appropriate study approach, gathering and organizing the data, performing the basic computations, and evaluating the quality of the results includes:

1. Define study objectives and consequent analysis needs.
2. Partition study area into analysis units to include watershed subunits, damage reaches, and floodplain units as needed.
3. Develop crop and crop loss data.
4. a. Develop hydrologic and hydraulic data needed for continuous record strategy, or

4. b. Develop hydrologic and hydraulic data needed for frequency based strategy.

5. a. Perform continuous record damage computations, or

5. b. Perform frequency metnod damage computations.

STUDY OBJECTIVES AND ANALYSIS NEEDS

Agricultural crop flood damage analyses are performed for a variety of reasons and for a wide range of geographical and economic settings. The objectives for performing the study will significantly influence the selection of an appropriate analysis strategy and the extent and detail of data collection. Several items that are significant in influencing other aspects of the study are: type of study, customer for the product, alternative damage mitigation measures to be studied, and reporting requirements.

Planning investigations will normally be either reconnaissance or feasibility studies (Chapter II). The goals of a reconnaissance study are to define the scope and nature of the flood problem and to determine whether a feasible solution is likely to be discovered in a subsequent feasibility investigation. The goals of a feasibility study are to formulate a solution to the flood problem, determine the costs and benefits, negotiate local participation requirements and arrange the funding through cost sharing agreements. The detail of flood damage analysis needed for each study type is quite different. An approximate, but conceptually sound approach, may be applicable for one but not the other.

The customer for the results of an agricultural flood damage analysis will most often be the Congress, through the Corps' reporting channel. Reporting requirements will, therefore, most often be well known. In other instances, for example where a local sponsor must respond to its governing constituency, local prevailing custom in crop flood loss analysis and reporting, in addition to the needs of the Corps' reporting channels, may need to be accommodated. If reporting flood loss during the occurrence of an event is needed for real-time water control, other Federal agencies, local governmental units, and the public are immediate recipients. These customers and their needs should be considered in selecting the analysis strategy and in reporting the results.

The flood loss mitigation measures that will be evaluated in the analysis should also be considered in the development of an analysis strategy. Reservoirs, for example, while reducing the depth and extent of flooding, can inadvertently increase the duration of flooding. An analysis strategy that explicitly includes direct accounting for the effects of duration would be essential. Channel projects have a lesser need to explicitly account for changed duration (it will likely be similar to the without-project condition, but slightly less). Many levee projects will completely eliminate flooding up to some planned protection level, but if the protection level is exceeded, damage may be similar to that under without-project conditions. The emphasis would, therefore, be on determining the crop flood damage under the without-project condition. For other levee projects, ponding of interior rainfall may result in residual damages that will need to be considered. Proposals that consider selectively protecting alternate sides of a stream (sometime to the detriment of the other side), or are implemented in selected locations, require an analysis strategy and detail that can directly determine the benefits from such protection schemes. Other measures have similar, unique analysis needs.

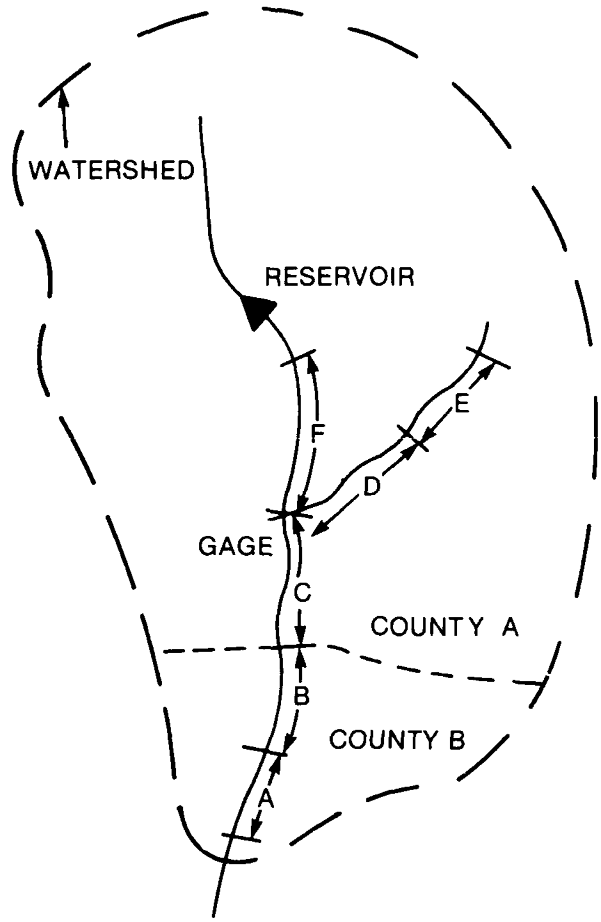
PARTITION STUDY AREA

The study area, both floodplain and contributing watershed, must be partitioned into analysis subunits to accommodate many data, analysis, and reporting needs (Chapter VII). Calculations of crop flood damage are performed for specific locations within the larger study area. Hydrologic and flood damage potential data must be developed and accurately aggregated for these locations to enable efficient and accurate computations to be performed. Defining the aggregation areas (they are normally referred to as damage reaches) and selecting a reference point (often referred to as the index location) within each area that is representative of the area should be done with care.

From the hydrologic engineering perspective, important factors that should be considered in defining the damage reaches and index locations are: locations of stream gages, locations of major watershed subdivisions (e.g., tributary boundaries or boundaries for computer watershed models), consistency in (parallel) water surface profiles for a range of flow, stability for developing rating curves, and hydrologic engineering information needs for flood-loss mitigation measure formulation and evaluation. Factors that are important from an economic analysis/crop characteristics perspective are: existing and future crop distributions, soil capability, data reporting boundaries (e.g., county or cooperative district boundaries), and economic information needs for flood-loss mitigation measure formulation and evaluation. Other factors that could be important include: local government/special district boundaries for which planning information will be reported, and boundaries used by the Corps or others in previous studies. A conceptual view of the watershed/study area partitioning is depicted in Figure IV-2.

CROP DATA AND CROP LOSS RELATIONSHIPS

The crop data needed for damage analysis (Chapter VII) can be loosely grouped into two categories: areal extent and mix of crop types; and cultural requirements, yield, and market value. The areal extent and crop mix is needed for determining existing and future conditions for with and without each project proposal, if they are different. The data should be tabulated for each damage reach. The data are normally presented as acreage by crop type for a range of water surface elevations at the index locations. Use of a reference flood -- a typical flood profile used in aggregating data to an index location -- is essential to accurately represent the areal extent/crop mix for the damage reaches.



SOME PARTITIONING CRITERIA

STREAM GAGE LOCATIONS
CATCHMENT SUBDIVISIONS
COMPUTATION POINTS
CONSISTENT PROFILES
GOOD INDEX LOCATIONS

CROP TYPES/LAND USE
SOIL CAPABILITY
REPORTING BOUNDARIES
POLITICAL SUBDIVISIONS
PREVIOUS STUDY BOUNDARIES

FLOOD DAMAGE MITIGATION
MEASURES

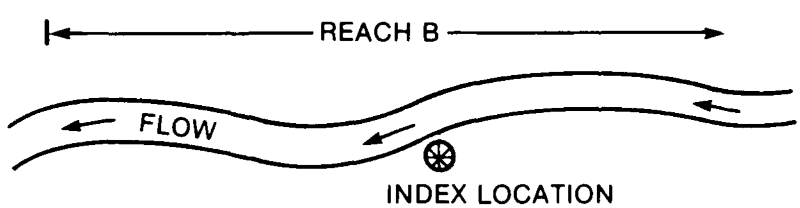


FIGURE IV-2 STUDY AREA PARTITIONING

Development of crop loss functions (Chapter V) are needed for each of the crop types that will be considered for the study. An example function was previously shown in Figure III-1 (page III-6). Note that it is a continuous function, representing crop loss potential throughout the land preparation - crop growth - harvest period. Supporting crop loss information needed includes: an auxiliary relationship defining the incremental increase in crop loss due to duration of flooding (Chapter VIII) and a supplemental procedure for considering multiple floods during an analysis period (Chapter V). These data and accompanying loss evaluation relationships are the essential economic information that, when merged with the hydrologic information, enable the crop damage analysis to be performed.

HYDROLOGIC AND HYDRAULIC ANALYSIS

As noted above, the continuous record and frequency methods are two alternative computational strategies commonly used in the damage analysis. Each is briefly described below, including advantages, disadvantages and data limitations. Although each is described separately, some combination of the techniques may produce the most accurate results for certain planning applications. For example, a 25-year period-of-record hydrologic data set may be the best information available to determine the characteristics of flooding (e.g., time of year, duration and recurrence) for a particular study area, but may not have contained any large, infrequent flood events. Some combination of the two techniques may, in this instance, be the most accurate method to incorporate the effects of these infrequent floods in the damage analysis.

CONTINUOUS RECORD METHOD

The basic hydrologic engineering information needed for the continuous record analysis method is a time trace of flood elevations for the period of record to be analyzed for all locations within the basin for which computations are to be performed. This is a deceptively simple information need. It could be easily supplied if a continuous stage recording gage existed at every location where flood loss computations are desired, and further, if the gages had been in continuous operation for a satisfactory period of time, say 100 years. Since this situation seldom exists, the hydrologic analysis goal is to develop such information based on available data.

The likelihood of there being recorded gaged stage data for a 100 year period is slight. Most record lengths are much shorter, on the order of 25 to 50 years is considered, by hydrologic engineers, to be good fortune. At best, only one long period record is likely to exist within a given study area. Some adjustments, either for location, length of record, or both, are virtually always required. It should be emphasized that the intended use of the continuous record is to compute flood losses that correspond to the historic record. The computations can, therefore, only consider floods of the magnitude included in the record. Short records, less than 10 years, are notoriously unrepresentative of possible flooding. They seem to either be dominated by a few extremely large floods or are absent of large floods. That is simply a consequence of the random nature of the flood process.

Several approaches are available to develop needed hydrologic information from incomplete data. A representative listing of these approaches, in the order of decreasing completeness of available data and, thus, decreasing reliability includes:

1. Transfer/adjust adequate record length stage data to desired location(s).
2. Extend short stage record in time.
3. Synthesize record from precipitation-runoff
4. Synthesize stage record through stochastic

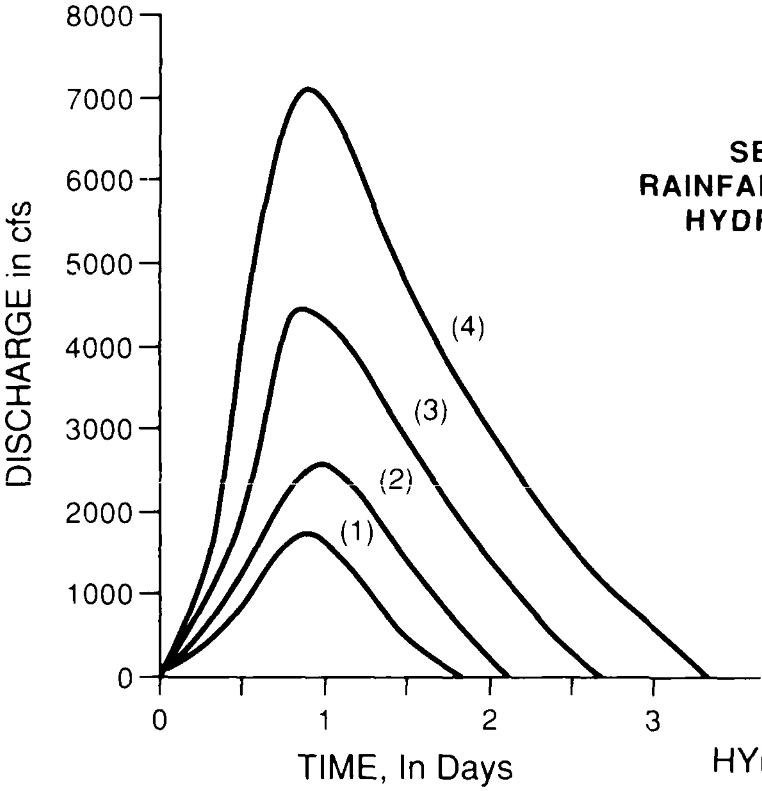
Regardless of the method used to develop continuous record stage hydrographs, the subsequent flood loss computations (described below) proceed identically. Since the record is judged to be adequately representative of flooding potential, frequency analysis is not required. The record is assumed to contain the full range of flood events that are possible in the proportion appropriate to the length of record. The continuous record approach is a traditional one within the Corps. Its appeal is that it is easy to understand and to explain to the public, works well in applications where sequences of multiple floods interacting with replanting are an issue (Chapter V), and has a history of use within the Corps. Its weaknesses are that it can be unduly demanding of resources to develop the continuous record data when gaged data are not readily available, and it can result in unreliable answers when the adopted record is unrepresentative.

FREQUENCY METHOD

The frequency-based flood loss computation approach develops the flood damage for hypothetical frequency flood events and weights the result to determine the expected annual damage. The hydrologic and hydraulic information needed are sets of "frequency" stage hydrographs, and exceedance frequency event relationships applicable for the locations for which damage is to be calculated. The approach does not use gaged data directly. Instead, the data are used to develop the coefficients needed to compute runoff hydrographs from specified precipitation patterns and to develop flood frequency relationships.

Frequency hydrographs are developed that represent the typical flood response of the watershed. If significant differences exist between seasons, for example rain-storm floods in the fall and winter and snowmelt floods in the spring, then two sets of frequency hydrographs are developed. Examples of frequency hydrographs for two seasons of the year are shown in Figure IV-3.

A frequency hydrograph is defined as a flow hydrograph for a specified exceedance frequency in which the peak, volume and all durations are statistically consistent. They can be developed from gaged data when a long record exists for the location of interest. Since this is seldom the case, synthetic relationships are normally used. Precipitation relationships derived from gages in the region or from nationally published technical bulletins are used to construct several synthetic storm events. A calibrated watershed model is then used to transform the storms into flood hydrographs. Several of these hydrographs are developed for a range of exceedance frequencies. Others can be interpolated to ensure complete coverage of the range of potential floods.



HYDROGRAPH NOMENCLATURE

(1) 50% Chance Exceedance Event
(2) 10% Chance Exceedance Event
(3) 4% Chance Exceedance Event
(4) 1% Chance Exceedance Event

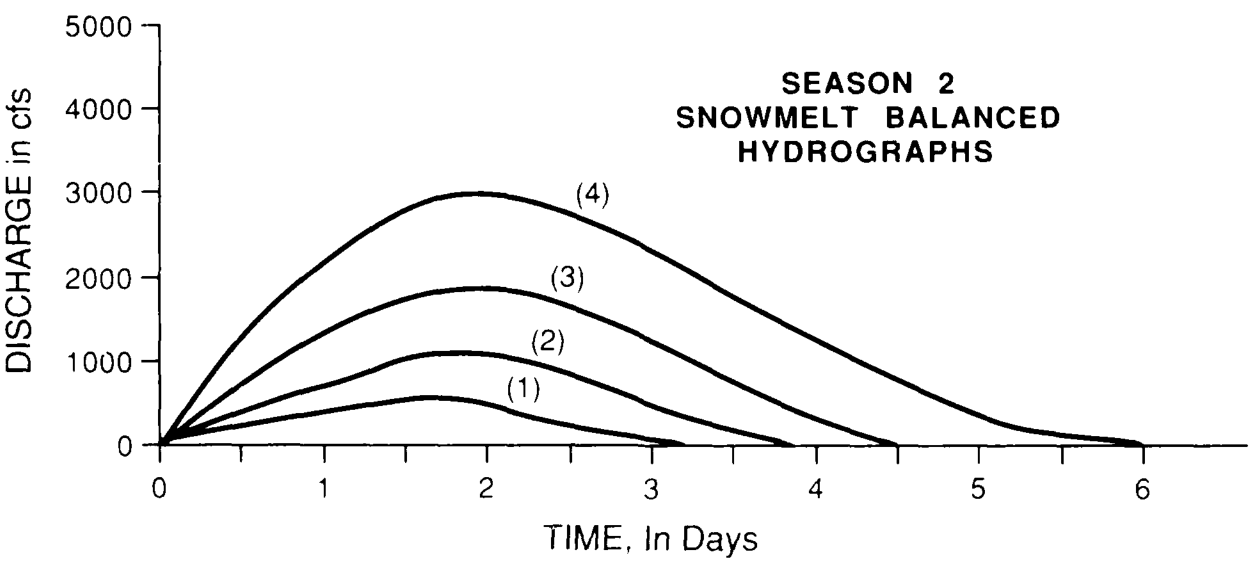


FIGURE IV-3 EXAMPLE FREQUENCY HYDROGRAPHS

The flow hydrographs are then translated to stage hydrographs by means of water surface profile computations. The exceedance frequency to be associated with each of these hydrographs is normally determined by associating the peak flow with a separately derived peak flow-frequency relationship, often referred to as simply a frequency curve. Two alternative methods are used to develop these frequency curves; the annual event method and the partial duration event method.

Annual event frequency curve. The annual event frequency curve is preferably developed from long-record gaged data. The highest peak flow each year is determined, and an exceedance frequency-flow relationship developed by either graphically plotting the results or from fitting a standard probability density function to the data. The frequency curve depicts the annual percent chance of exceedance for the full range of peak flow flood events. An example of an annual maximum event peak flow frequency curve is provided in Figure IV-4 (Curve A).

When sufficient gaged data are not available, synthetic watershed computations are required to develop the annual event frequency curve. Storm events are constructed from published precipitation data and the exceedance frequency of the resulting flow is determined from the storm precipitation used in the computations. The resulting frequency curve is considered to be significantly less reliable than one developed from a long-term gaged record.

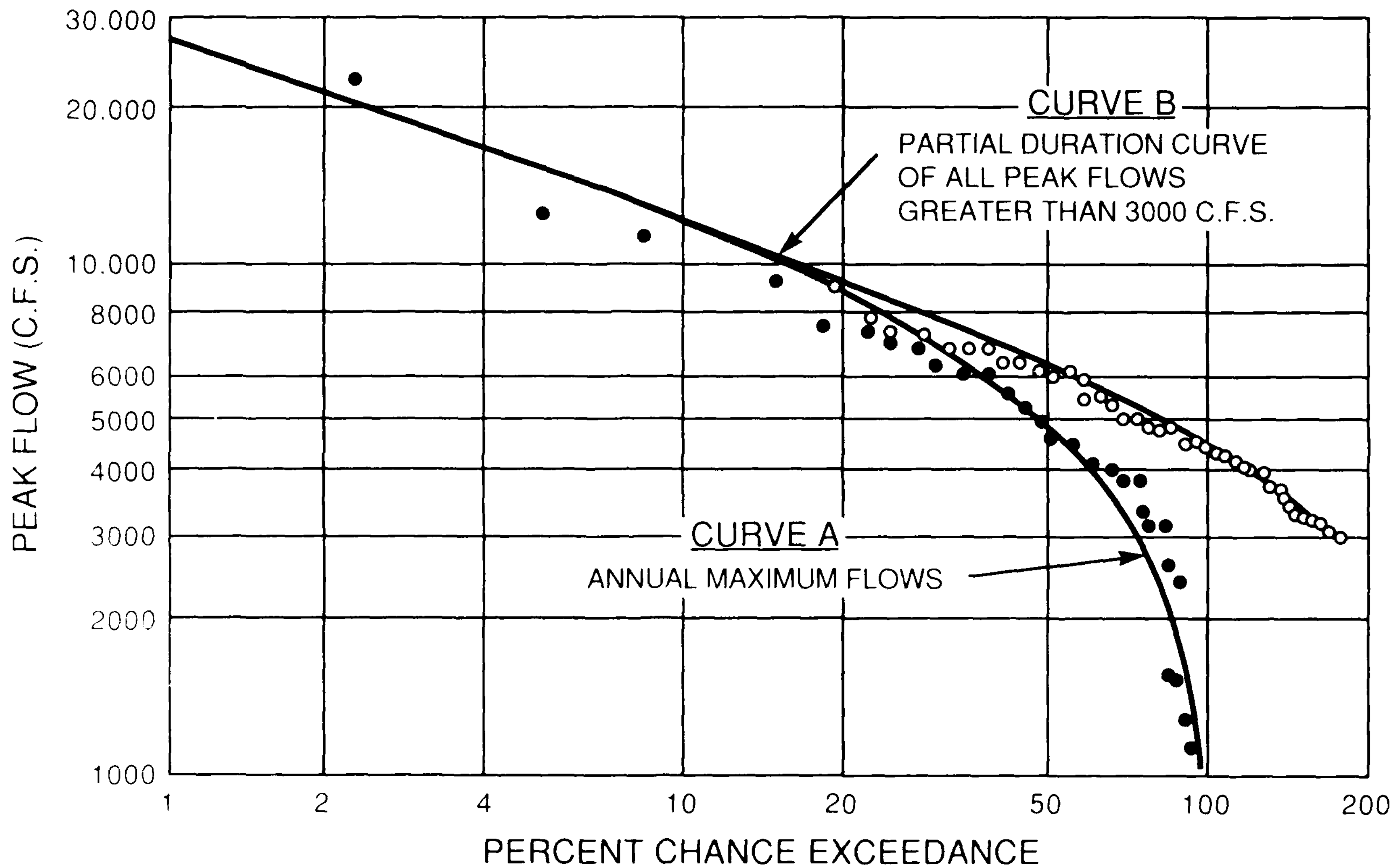


FIGURE IV-4 EXAMPLE EXCEEDANCE FREQUENCY CURVES

Partial duration frequency curve. A partial duration frequency curve is derived from an array of flow data that is also extracted from a gaged record. Instead of taking the single highest peak flow for each year, all peak flow events above a threshold flow are extracted and tabulated. More than one event in any year may be used. The result is a frequency curve that looks like the annual event curve, except it flattens out at the more frequent end. It often can be read for event frequencies more often than once per year. An example of a partial duration curve, as compared to an annual event curve, is also provided in Figure IV-4 (Curve B).

Where flood damage can be caused by flood events that can occur, on the average, more than once per year, use of the partial duration frequency method is necessary. Caution should be used, however, when applying the curves for damage computations for events significantly more frequent than the annual event (100 percent exceedance frequency). Flood damage from these more frequent events will be weighted very heavily in determining the expected annual damage. For example, damage from the one percent chance event (the 100-year flood) is weighted by .01, while damage from the twice per year event (exceedance frequency of 200 percent) is weighted by 2.0, or two hundred times as much contribution to the expected annual damage.

Multiple flood events. When using the frequency method, a relationship is needed to adjust for multiple floods occurring within the same year where this is likely to be an important factor. Whether expected annual damage estimates are adjusted upward or downward will, generally, depend on whether annual or partial duration frequency curves are used in the analysis (see Chapter V).

Seasonal events. A relationship is also needed, when using the frequency method, to adjust for the probability of floods occurring by season. This is needed to weight the damage computed for the frequency hydrographs by season to develop an annual value (Chapter VIII). The most straight forward means of developing the seasonal probabilities is to simply examine a historic gaged record in the area and compute the proportion of the total flood events that fall within each defined season.

PERFORM CONTINUOUS RECORD DAMAGE COMPUTATIONS

Continuous record damage computations, in effect, convert the stage hydrograph to a crop flood damage-time relationship, that is then averaged to determine the expected annual damage and benefits (Chapters V and VIII). Briefly the essential elements are:

o Divide the elevation-area-crop mix relationships into elevation zones so that the incremental area for each crop type by elevation is known.

o Divide the flood event stage hydrograph into the same elevation zones and compute flood duration for each zone.

o Compute the crop damage associated with the event being analyzed for each crop and zone (damage by crop and by time of year). The calculations are based on the season, percent crop loss for the duration of flooding, and crop loss function. The total damage for each event is determined by summing the totals for the several flood (elevation) zones.

o Repeat the computation process for each event in the continuous record for each damage reach.

o Sum the damage for each event by crop type. Compute the average (expected) annual damage by dividing the total sum of damage for all events by the number of years in the continuous period of record.

The issue of seasonality is resolved directly, since damage is computed for the events as they occur. Duration and multiple flood events within a year are, likewise, directly considered. Accounting for double cropping can be accomplished in the development of the crop loss function.

PERFORM FREQUENCY-EVENT DAMAGE COMPUTATIONS

Frequency event damage computations develop flood damage for each of a specified set of frequency hydrographs. The resulting damage estimates are weighted by an assigned exceedance frequency to determine the expected annual damage and benefits (Chapters V and VIII). Briefly, the essential elements are:

o Divide the elevation-area-crop mix relationships into elevation zones so that the incremental area for each crop type for each elevation zone is known.

o Divide each frequency stage hydrograph into the same elevation zones and compute flood duration for each zone.

o Calculate the individual seasonal damage associated with each frequency hydrograph being analyzed for each crop and zone (damage by crop and season). The calculations are based on the season, percent crop loss for the duration of flooding, and crop loss function. The total damage for each frequency hydrograph is determined by summing the totals for the flood zones.

o Repeat the computation process for each frequency hydrograph for each damage reach.

o Develop the frequency event weighted season damage value by multiplying the proportion of time the event has occurred in each season by the seasonal damage previously calculated.

o Sum the weighted season damage values to obtain the total frequency event damage by crop and damage reach.

o Develop the frequency damage relationship by assigning the damage for each frequency hydrograph with the exceedance frequency that was adopted in the hydrologic computations. Calculate expected annual damage for each crop by integrating the frequency-damage relationship.

o Adjust expected annual damage value for within-year, multiple flood replant factors developed in the hydrologic analysis.

The issue of seasonality is resolved by performing damage computations for the frequency hydrographs for all seasons then weighting the results by the probability that flooding occurs within each season. Duration is directly included in a manner very similar to the continuous record method. Within-year multiple flood events must be handled by the development of an auxiliary relationship.

CHAPTER V

AGRICULTURAL CROP DAMAGE FUNCTIONS

The determination of agricultural crop flood damage is based upon the relationship of the timing of the flood incident and the stage of the crop production activities. The previous chapter provided an analytical framework for determining crop flood damage, as well as a brief description of the hydrologic concepts and data required. This chapter describes how to incorporate the relationship between stage of crop production and timing of flooding into this analysis. Much more detailed examples of the overall computational process are provided in Chapter VIII.

SEASONALITY OF CROP PRODUCTION INVESTMENT/EXPENSES

Flood damage to agricultural crops is dependent on the type of crop and the time-of-year and physical characteristics of the flood event. The loss potential of a particular crop varies throughout the year, based on production costs incurred and replant capability. The analytical tasks are to determine when production costs are incurred during the growing season and to relate this information to the seasonal damage susceptibility of the crop and hydrologic data of the area. Additional parameters important to the analysis include date and duration of flood events, multiple flood events during the year, and dry out periods required prior to replant.

Crop loss (damage) functions, such as previously illustrated in Figure III-1 (page III-6), are commonly used to depict variations in the damage potential of crops throughout the year. The functions describe a relationship between day-of-year and potential loss. The potential loss may be measured in dollars per acre, or as a percentage of the maximum damageable value of the crop. As described below, crop loss functions are based on farm budget analyses (Chapter VII) and typical management practices in the area under study.

DAMAGE VALUE

An example[1] crop budget (for 140 bushels per acre corn) is presented in the left side of Table V-1. The maximum damageable value of a crop is the gross value (yield x normalized price) less variable harvest costs. Variable harvest costs are not included, since they are either incurred prior to a flood (hence eliminating the crop damage potential) or are not incurred because the flood preceded harvest, resulting in loss of crop. For the corn example in Table V-1, the gross value per acre is \$357.00 (140 x \$2.55), the variable harvest cost is \$31.25, and the maximum damageable crop value is \$325.75. For purposes of flood damage analysis, this value must be further disaggregated into direct production and income components (right side of Table V-1).

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[1]The example data included in this chapter are provided for illustrative purposes only. Cultural practices and planting dates very significantly throughout the nation. Appropriate regional data must be used in study applications rather than the illustrative data presented in this manual.

TABLE V-1

EXAMPLE OF CROP BUDGET AND FLOOD LOSS POTENTIAL[1]

(Dollars per acre for 140 bushels per acre corn)

Production Item	Costs: Total	Costs: Fixed	Costs: Variable	Flood Loss Potential: Direct Costs[2]	Flood Loss Potential: Income Loss	Flood Loss Potential: Total
Preharvest Machinery	24.90	16.05	8.85	8.85	16.05	24.90
Seed/Chemicals/etc.						
Seed @ $63/bag	19.70		19.70	19.70		19.70
Nitrogen @ $0.14	16.10		16.10	16.10		16.10
Phosphate @ $0.23	16.10		16.10	16.10		16.10
Potash @ $0.12	8.40		8.40	8.40		8.40
Lime (annually)	5.00		5.00	5.00		5.00
Herbicide	14.75		14.75	14.75		14.75
Crop insurance	5.50		5.50	5.50		5.50
Miscellaneous	5.00		5.00	5.00		5.00
Interest on pre-harvest costs	9.30		9.30	9.30		9.30
Subtotal	99.85		99.85	99.85		99.85
Harvest Machinery						
Combine	27.20	17.50	9.70		17.50	17.50
Haul	6.70	3.50	3.20		3.50	3.50
Dry	26.60	9.80	16.80		9.80	9.80
Handle	4.05	2.50	1.55		2.50	2.50
Subtotal	64.55	33.30	31.25		33.30	33.30
Labor	19.20	5.00	14.20	14.20	5.00	19.20
Real Estate Taxes	20.53	20.53			20.53	20.53
Return to land and Management	127.97	127.97			127.97	127.97
TOTAL (per acre)	357.00	202.85	154.15	122.90	202.85	325.75
TOTAL (per bushel)	2.55	1.45	1.10	0.88	1.45	2.33

[1] Adapted from budget from Iowa State University, Ames, Iowa

[2] Direct Production Investment.

Direct production costs. The first damage component includes those variable production costs needed to bring the product to market. These costs are often referred to as Direct Production Investments (DPI) and, in this example, include: seedbed preparation, chemical and fertilizer application, hired labor, imputed labor costs for unpaid labor, equipment costs, seed, planting/sowing, weed and pest control and preharvest financing costs. They total $122.90 per acre (Table V-1) in the corn example. When flooding occurs for a critical duration, direct production costs incurred become flood losses.[2] If time is available for replant, these costs may be incurred again. If a subsequent flood occurs after the replant period, the direct production investments, or a portion thereof, may be lost again.

Income losses. The second damage component is the remaining damageable value of the crop, that is the difference between the damageable value and direct production costs. It represents net income plus return to such fixed items of production as land, labor and management, real estate taxes, and fixed costs associated with preharvest and harvest activities. Potential income loss is $202.85 per acre (Table V-1) in the corn example. Income loss associated with a particular flood event depends on the potential for replanting, as well as whether or not replanting would result in reduced yields.

[2]To simplify the conceptual presentation in this chapter, a 100 percent loss of crop is assumed. Methods for adjusting crop loss functions to account for varying damage susceptibility by season and/or duration of flooding are described in Chapter VIII.

CROP DAMAGE FUNCTIONS

Production cost functions. Potential direct production crop loss (the first damage component discussed above), varies throughout the crop year based on the cumulative total of production costs incurred at the time of the flood event, less harvest activity. This functional relationship for the corn example is depicted in Figure V-1. It is derived from detailed crop budget expenditure schedules (Chapter VII) based on typical cultural practices in the study area. The functional relationship may be derived from seasonal, monthly or more frequent summaries of budget expenditures. The more detailed the expenditure schedule, for example an average daily investment function, the more precise the analysis. The function in Figure V-1 is based on 15-day expenditure patterns (Full Season column of Table V-2).

The functional relationship in Figure V-1 indicates that, in this example, potential direct production crop loss increases through the crop year until it reaches a maximum value of $122.90 on July 15th. This would be the date by which all variable production costs for corn (excluding harvest costs) would typically be incurred in this study area. The potential direct production crop loss remains at this value until the beginning of harvest, September 15th. It is then reduced by the cumulative proportion of the crop harvested (again, based on typical cultural practices in the study area), through the completion of harvest, November 15th, in this example.

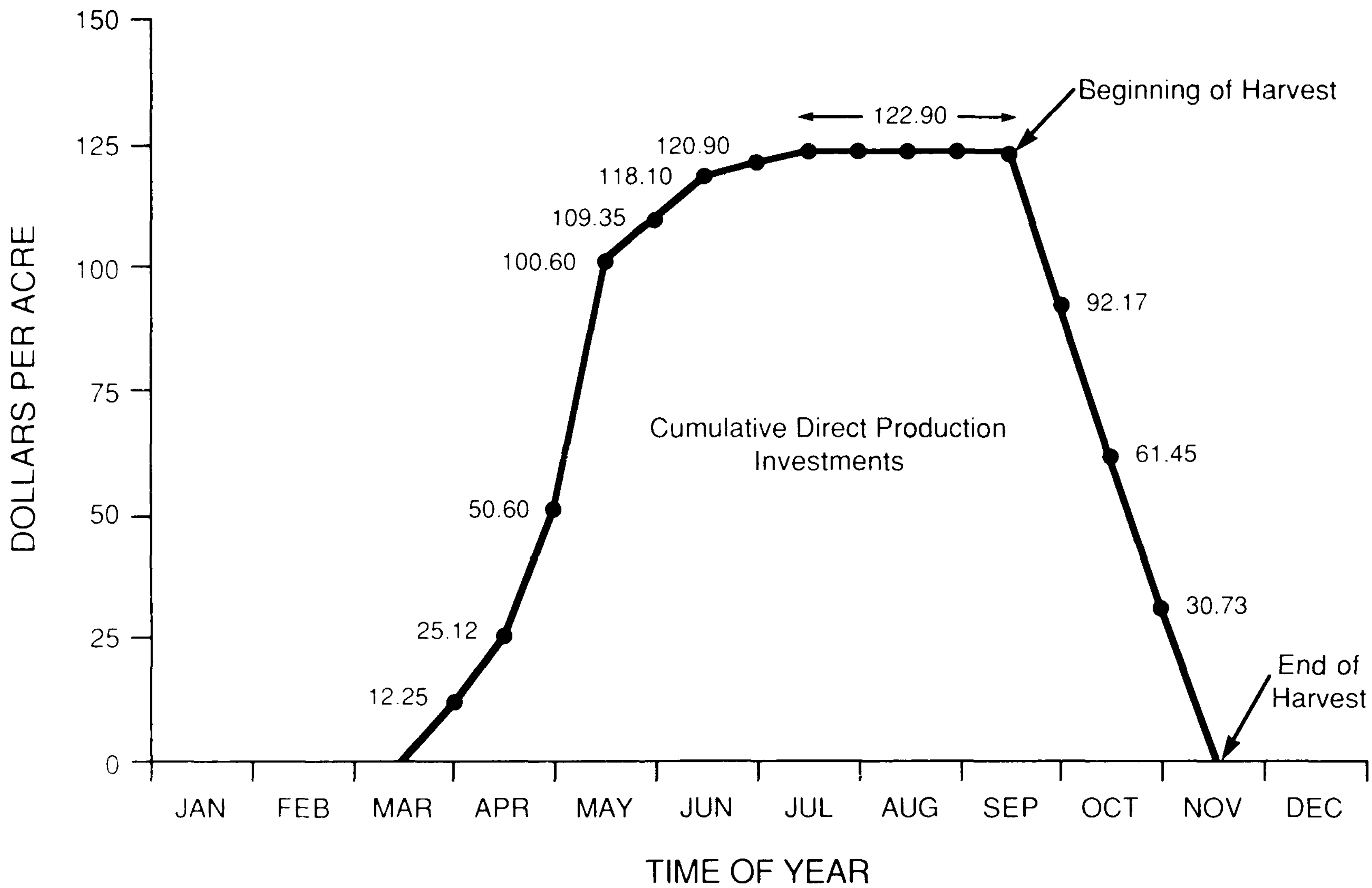

FIGURE V-1 EXAMPLE OF POTENTIAL DIRECT PRODUCTION LOSS FOR CORN

TABLE V-2

CUMULATIVE PRODUCTION EXPENSES SUBJECT TO FLOOD LOSS
(Dollars per acre)

Date	Full Season	Early Replant	Replant	Late Replant
Apr 1	12.25			
Apr 15	25.12			
May 1	50.60	50.60		
May 15	100.60	100.60	50.60	
Jun 1	109.35	109.35	82.01	50.60
Jun 15	118.10	118.10	88.58	88.58
Jul 1	120.90	120.90	90.67	90.67
Jul 15	122.90	122.90	92.17	92.17
Aug 1	122.90	122.90	92.17	92.17
Aug 15	122.90	122.90	92.17	92.17
Sep 1	122.90	122.90	92.17	92.17
Sep 15	122.90	122.90	92.17	92.17
Oct 1	92.17	92.17	69.13	69.13
Oct 15	61.45	61.45	46.09	46.09
Nov 1	30.73	30.73	23.04	23.04

The crop damage function in Figure V-1 is used to determine the potential direct production crop loss associated with the initial seasonal planting. Time permitting, farmers will often replant their crops following a flood event to regain a portion, or all, of their income loss. The direct production costs incurred from these replants can also be lost if subsequent flood(s) occur. To evaluate multiple flood events, especially when using the period of record hydrologic approach, direct production cost functions for typical replant cycles must also be developed.[3]

[3] Again, to simplify the conceptual presentation only replanting with the same crop (corn) will be considered here. Replanting with other crops can easily be incorporated into the analysis.

Cumulative production expenses for typical replant cycles for the corn example are also presented in Table V-2. As with the initial planting, they are based on crop expenditure schedules and typical cultural practices in the study area. Data from Table V-2 are used to develop a series of potential direct production cost damage functions, Figure V-2. In this example, the series of functions describe the daily potential production cost damage associated with initial planting and early, regular, and late replant cycles. It is also assumed, in this example, that the latest date for initiating a replant is mid-June. How these functions are used to estimate potential damage associated with a specific flood or series of flood events is described later in this Chapter in the Period of Record Analysis Section.

Potential income loss functions. As described above, the second component of the damageable value of the crop is potential loss of income It is defined as the difference between the total damageable value of the crop and direct production costs. Whether or not a portion or all of the potential income component will be lost due to a particular flood event will depend on whether or not farmers have time to replant following the flood to recoup a portion, or all, of their potential income loss.

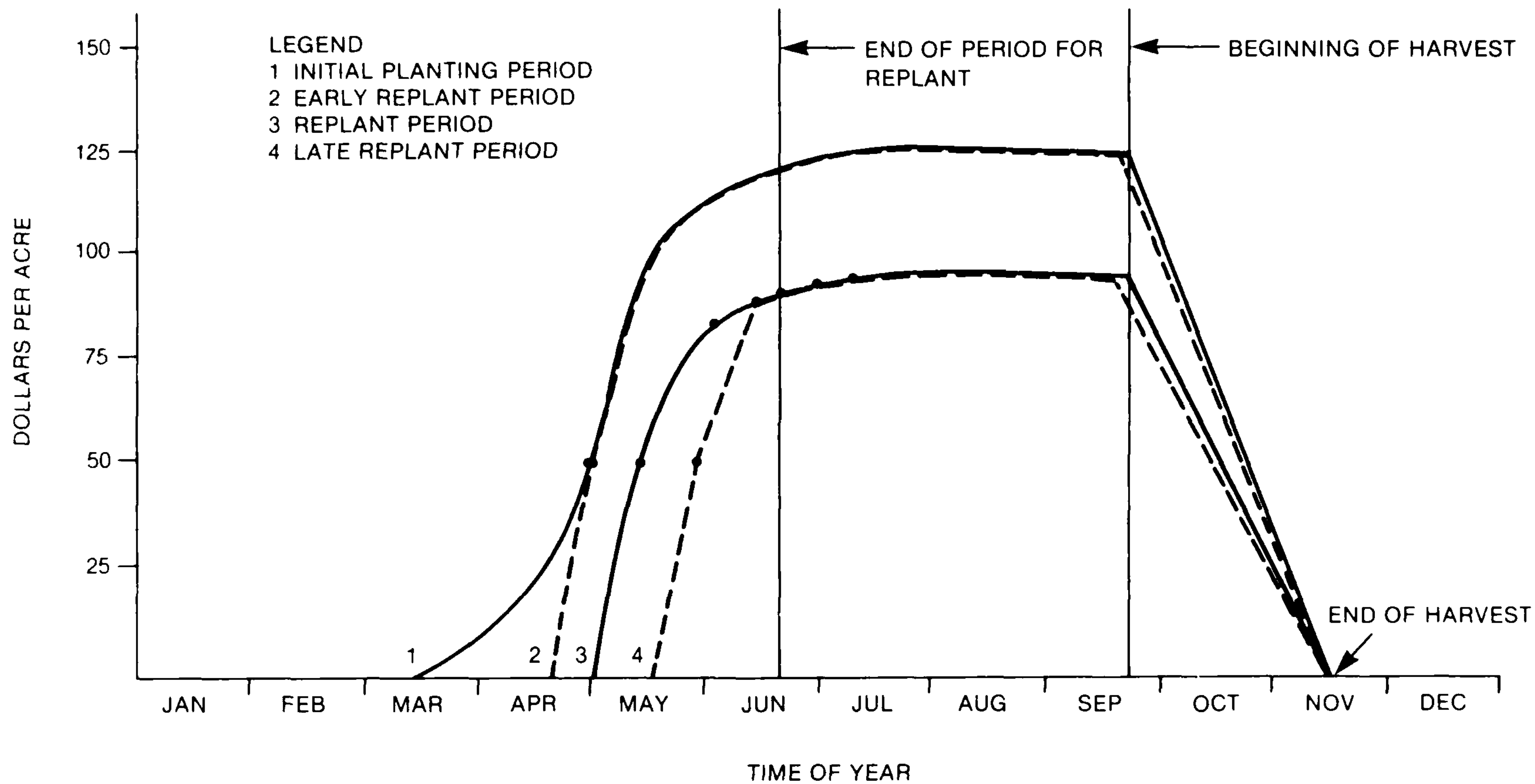

FIGURE V-2
EXAMPLE POTENTIAL DIRECT PRODUCTION CROP LOSS FOR CORN FOR INTITIAL PLANTING AND TYPICAL REPLANT PERIODS

To evaluate the income component, a series of potential income loss functions are developed, somewhat similar to the potential direct production cost loss functions, for typical replant periods in the study area. The maximum potential income loss for the corn example was previously estimated to be $202.85. This is the potential income that can be earned, in this example, from crops where planting (or replanting) is initiated by the end of April. Because of a shorter growing season, crops with replanting initiated after the end of April will have reduced yields, and, therefore, a reduction in potential income that could be lost to subsequent flood events. For this example, it is assumed that the remaining replant periods and associated potential income losses are: crops with replanting initiated 1-14 May have a potential income loss of $182.57; 15-30 May, $162.28; 1-14 June, $152.14; and after mid-June it is to late to initiate replanting.

The potential income loss functions for the corn example, based on the above information, are depicted in Figure V-3. The uppermost function in Figure V-3 indicates that for crops with <u>planting</u> initiated by the 30th of April, the potential income loss is $202.85 until the beginning of harvest on 15 September. As with potential direct production cost losses, once harvest begins the potential income loss is reduced by the cumulative proportion of the crop harvested. This initial function assumes that, as long as replanting begins by the end of April, adequate time remains in the growing season such that there will not be any reduction in yield or loss in potential income. Thus, there will not be any <u>income</u> loss associated with those flood events where replanting can be initiated prior to 1 May.

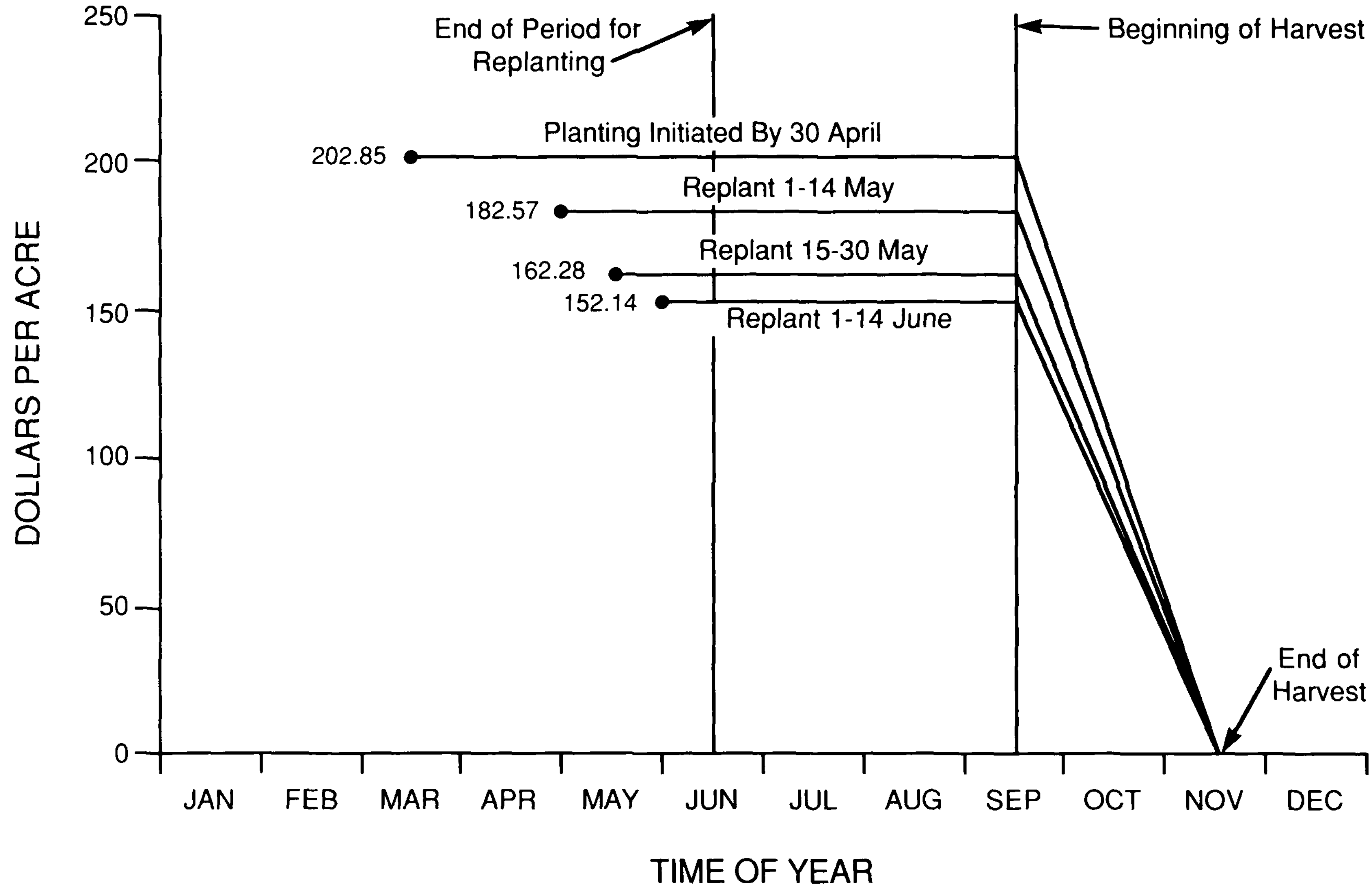

FIGURE V-3 EXAMPLE POTENTIAL FLOOD DAMAGE INCOME LOSS FOR CORN

The next lower function in Figure V-3 indicates that for crops with planting initiated 1-14 May the potential income loss is $182.57 until the beginning of harvest, after which it is similarly reduced by the cumulative proportion of the crop harvested. This indicates that reduced yields and income losses will be associated with flood events that delay replanting beyond the first of May. The remaining functions depict similar information for the other replant periods. The income loss for a particular event is equal to the income loss from the crop flooded less the potential income from the replanted crop. Detailed examples of such calculations are provided in the following section.

PERIOD OF RECORD ANALYSIS

If adequate hydrologic information is available, the period of record analysis offers the potential for a more detailed simulation type approach to damage analysis than the frequency method. One distinct advantage of this method is that it can directly simulate multiple flood events for damage analysis.

An overview of the continuous or period of record computational process was provided in Chapter IV. Basically, the historic hydrologic and hydraulic data provide a physical description of flood events that have occurred over a long period of time. Estimating the flood damage that would be associated with each flood event, summing over all events, and dividing by the number of years in the continuous record, provides an estimate of expected annual damage. The following discussion illustrates how the previously developed production investment and income loss functions are combined with certain physical flood descriptions to incorporate the seasonality of flood damage potential and the effects of multiple flood events into the damage analysis.

When using the period of record analysis, each flood event is described in terms of a start date and inundation and dry out periods. (For most analytical programs, floods are also described in terms of acres flooded per day; that information is not, however, needed for the conceptual presentation of this chapter). Briefly, the start date determines the amount of production investment subject to loss. The inundation and dry out periods determine when (if) replant will occur. The latter is needed, not only to estimate the income loss of the flood event being analyzed, but also the appropriate potential production investment and income loss functions to use in analyzing subsequent flood events. Specific examples for estimating damages per acre from both single and multiple flood events are described in the following paragraphs. These examples are based on information provided in Table V-3, and are presented on a dollar loss per acre basis.

TABLE V-3

EXAMPLE OF FLOOD DAMAGE COMPUTATIONS

Flood Characteristics				Flood Damage[1]		
Start	End	Dry out	Start Replant	Production Expenses	Income Loss	Total
Single Event						
Apr 1	Apr 5	Apr 15	Apr 15	12.25	0.00	12.25
May 15	May 20	Jun 1	Jun 1	100.60	50.71	151.31
Jun 15	Jun 25	Jul 5	Too late	118.10	202.85	320.95
Oct 1	Oct 15	Nov 1	Too late	92.17	152.14	244.31
Multiple Events						
Apr 1	Apr 5	Apr 15	Apr 15	12.25	0.00	12.25
May 1	May 5	May 15	May 15	50.60	40.57	91.17
Jun 15	Jun 25	Jul 5	Too late	88.58	162.28	250.86
			Total	151.43	202.85	354.28

[1] Dollars per acre

SINGLE FLOOD EVENT

The first four examples in Table V-3 relate to single flood events, that is only one flood event occurs during the crop year. Only the uppermost expense function in Figure V-2 is needed to analyze direct production investment loss for a single flood event. The production investment loss, (i.e., the cumulative total of direct production costs incurred) is determined from this function based on the starting date of the flood being analyzed. For the four single event floods in Table V-3, the flood start dates are 1 April, 15 May, 15 June, and 1 Oct; the respective flood damage production expense losses are (from the uppermost function in Figure V-2) $12.25, $100.60, $118.10, and $92.17. It should be noted that the last flood event occurred after harvest had begun. The maximum production losses that could be incurred ($122.90 in this example) are, therefore, reduced by the estimated proportion of the crop harvested to determine the actual production losses that would be incurred.

Similarly, for income losses under single flood events, only the uppermost potential income loss function is needed to determine the <u>potential</u> income loss for the inundated crop. However, the inundation and dry out periods are also needed to determine the timing of replant, if possible, and, if so, the income that could still be earned from the replanted crop. This latter value must be subtracted from the potential income loss of the inundated crop to determine the flood damage income loss actually incurred.

For example, the first single event flood described in Table V-3 has a start date of 1 April. The income loss for the inundated crop is $202.85. The flood ends on 5 April and the fields are dry enough for replanting by 15 April. With a replant date of 15 April, the income potential of the replanted crop is still derived from the uppermost function (replant precedes 15 May) and is also $202.85. The income loss associated with this flood event is, therefore, $0.00 ($202.85 - $202.85). Total damage associated with this flood event would just result from the loss of production expenses and would equal $12.25 as described above.

For the next three single flood events, some loss of income will occur. For the flood beginning 15 May, replant will begin on 1 June. The potential income that can be earned from this crop is $152.14 (from lowest potential income loss function in Figure V-3). The income loss is then $50.71 ($202.85 - $152.14), and total damage is $151.31. For the next single event flood, replant could not begin until 5 July, too late for a crop to be planted. Since the flood event occurs before harvest has begun, the maximum potential income loss of $202.85 is incurred, total flood damage is $320.95. The last single event flood also occurs too late for replant. However, the start date for this flood is October 1, following the 15 September date for the beginning of harvest. For this flood event, the maximum potential income loss is reduced by the cumulative proportion of the crop harvested. The flood damage income loss is still derived from the uppermost function. For a flood date of 1 October the income loss is $152.14, and total flood damage is $244.31.

MULTIPLE FLOOD EVENTS

The last example in Table V-3 relates to multiple flood events, that is more than one flood occurs during the crop year. This is a real advantage of the period of record analysis, the ability to simulate how previous flood events change the potential damage regime for subsequent events.

For the multiple flood example, the first flood event is the same as described for the first single flood event scenario, and the damage calculation is the same. There is a $12.25 production investment loss, but no loss of income. The important factor to remember is that the replant following this first flood began on April 15. This date identifies the appropriate production investment and income loss functions to use in analyzing flood damage from the subsequent flood event.

The second flood event begins on May 1, with replant beginning on May 15. The direct production investment loss of $50.60 is derived from the potential crop flood damage production cost function in Figure V-2 that begins with an April 15 replant date. Based on the appropriate functions in Figure V-3, loss of income for a crop replanted on April 15 is $202.85, and the potential income that can be earned from a crop replanted on 15 May is $162.28. Income loss associated with this second flood event is $40.57 ($202.85 - $162.28), and total flood damage is $91.17.

The third flood event during the year begins on June 15 with the fields not drying out in time for replant. Direct production investment loss of $88.58 is derived from the potential crop flood damage production cost function in Figure V-2 that begins with a 15 May replant date. From Figure V-3, potential income loss for a crop replanted on 15 May is $162.28, all of which is lost since replant is not possible. Total damage associated with this final flood event is $250.86. The total flood damage that occurred during the crop year from this multiple flood event series is the sum of the damages from the three separate events, or $354.28 per acre, ($12.25 + $91.17 + $250.86).

FREQUENCY ANALYSIS

As described in Chapter IV, frequency based flood loss computations develop flood damage estimates for each of a specified set of frequency hydrographs. These damage estimates are then weighted by an assigned exceedance frequency to determine expected annual damage. Since the weighing is only based on the probability of an event occurring, not whether or not a previous flood has already occurred in the crop year, the effect of multiple flood events cannot be explicitly incorporated into the damage analysis. The seasonality of potential flood losses, however, can and should be.

To incorporate the seasonality of flood damage into the analysis, individual seasonal damage estimates are made for each flood hydrograph. Typical seasonal start date and inundation and dry out periods are needed similar to those used in the period of record analysis. Seasonal estimates for production investment and income loss can then be made, using the same functions and procedure described above for single flood events under the period of record analysis. As described in Chapter VIII, these estimates are then weighted by the proportion of time the event has occurred (or is expected to occur) in each season and summed to get an estimate of the total frequency event damage.

As described in more detail in Chapter VIII, expected annual damage is then derived by combining the frequency damage estimates with exceedance frequency information. Although the seasonality of flooding will be accounted for in the expected annual damage computations, the effect of multiple flood events will not, and some adjustment based on local conditions may be required. The direction of the adjustment will depend on whether annual or partial event exceedance frequency information (Chapter IV) is used.

As described above, the single event damage estimate procedures are used with the frequency analysis approach. If partial event frequency data are used, the flood damage for all events is estimated assuming no previous event has occurred. For years with multiple events, the potential loss for later events may be reduced because late replants result in both loss of yields and reduced production investments. Thus, a reduction in the expected annual damage may be required.

Annual event frequency data are based on the largest event that occurred each year. It may underestimate the probability of smaller, more frequent events that still result in flood damage. Use of annual event frequency data may, therefore, require an increase in the estimate of expected annual damage.

CHAPTER VI

EVALUATION OF BENEFITS FOR PREVENTING NON-CROP FLOOD LOSS

Prevention of non-crop flood loss can account for a significant portion of benefits for some agricultural projects. The procedures for the calculation of damage to buildings, roads, and some nonphysical damages are similar to the procedures for urban projects. However, estimation procedures for machinery, livestock, stored grain, fertilizers, seed, ditches, and fences are unique and require specialized knowledge of inventory procedures and damage susceptibility. This chapter describes some of the unique considerations important to the evaluation of non-crop farm losses.

FARM BUILDINGS

STRUCTURES

Evaluation procedures for farm buildings, including houses, barns, sheds, and silos, are the same as would be followed for urban property. Inventory consists of recording the building's use, the number of stories, the value, and the elevation of the structure. (Note: Additional information on the estimation of flood damage reduction benefits to residential, commercial, and industrial properties is available in the National Economic Development Procedures Manual Urban Flood Damage, currently in print.)

Structure values. Values should be based upon the "depreciated replacement" cost of the property. This means that the value of a structure should be estimated to equal the cost of constructing a building with the same physical attributes, adjusted downward to reflect any physical deterioration or functional obsolescence.

One useful source for obtaining depreciated replacement value is to use an assessment manual or data base, such as provided by the Marshall Valuation Service. The Marshall Valuation Service provides monthly information for estimating structure and fixture replacement values for houses, barns, silos, grain elevators and sheds. Depreciated replacement values can be determined to var[illegible] degrees of precision by following the survey forms in the Marshall Valu[illegible] Manual. The surveys include information on size, condition, style, materia[illegible], and amenities. This information can be obtained from on-site inspections or interviews using Office of Management and Budget (OMB) approved questionnaires. This information can be input into the Marshall Valuation Service through on-line entry or through formula for each value as defined in the Valuation Manual.

Marshall-Swift provides data for two different methods of computing property values: the segregated cost and calculator methods. The segregated cost method is based on a complete reconstruction of building cost data by component. The replacement cost per square foot is determined by adding [illegible] value of floor area components such as foundation material, [illegible] and cooling system, outside walls, and roof costs.

The calculator method is the simpler [illegible] square foot are obtained simply [illegible]

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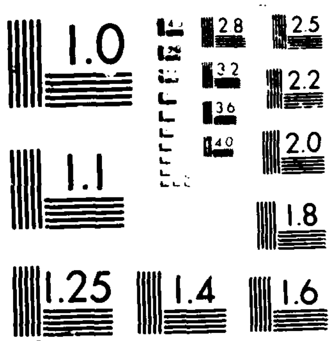
1.0
2.8
2.5
3.2
2.2
3.6
2.0
4.0
1.1
1.8
1.25
1.4
1.6

class, and condition. Five classes of buildings have been devised, based on construction type. Refinements to the estimates can be made based on several factors, such as number of stories, height of story, and type of heating and cooling system.

Values for both the segregated costs and calculator methods are depreciated by deducting a percentage from a life expectancy table specific to each type of structure. Depreciation is based on the normal expected life, the condition, and functional obsolescence.

Where study funds and time are limited, market values can be used to approximate depreciated replacement value. Market values of residential property are easily obtained from public records of recent sales, which may either be kept with the county recorder of deeds or the tax assessor's office. The value of an urban home can be determined by subtracting land values, which are determined after comparison with the market value of comparable vacant land. It is somewhat more difficult to estimate the value of farmhouses, because the values of all improvements, including houses, barns, silos, sheds, and fences will be lumped together. The tax assessor will also have records of assessed valuation, with separate values given for land and improvements. The assessed valuations are made at a fixed percentage that is usually less than 100 percent of the market value and needs to be adjusted accordingly. For example, if a structure is assessed at 60 percent of market value, then the assessment should be multiplied by 1.67 to determine the approximate market value.

Content values. Content/structure value ratios for residential property are somewhat consistent. This ratio generally falls between 40 and 50 percent. Protection exceeding a 100-year frequency will allow this ratio to go as high as 75 percent.

Depth-damage relationships. Generalized depth-damage relationships developed from post-flood surveys or synthetic estimates of probable damages can be applied or estimates can be made which are specific to the study area. In either case, damage functions should be verified by comparison with damages observed in post-flood damage surveys.

The nature of the structure and contents and the susceptibility of farm houses to damage can be expected to be no different than for urban houses. The same depth-damage functions used for urban residential structure and contents should apply. Generalized damage functions computed by some Corps districts or the 1974 Federal Insurance Administration depth-damage functions should be applicable.

Cleanup. In addition to the structural and content damage estimates described above, cleanup costs should also be included in the flood damage estimates. Urban depth-damage functions will usually, but not always, include estimated clean-up for each level of flood inundation. Clean-up costs should include 1) direct costs of cleaning service, 2) the total number of hours spent cleaning by each household times the average local costs of custodial labor, and 3) the direct costs of cleaning material.

STORED CROPS

Farmers who operate small farms or inhabit broad floodplain areas often store sizeable quantities of harvested, but unprocessed, crops in the floodplain. It is generally unlikely that any of the stored grain would be removed, unless there are at least several days warning prior to a flood event. In these cases, the significant costs of moving the crops should be considered.

Silos are the primary type of chamber used for storage; however, small bins and plastic casings can also be used. All stored grains can be expected to have similar degrees of susceptibility. That is, excessive moisture will force the disposal of the grain. Moisture can occur to the entire contents of a silo or bin from as little as one foot or less of inundation, due to the capillary action of the water and if driers do not adequately maintain a low humidity. The evaluator should also be aware of hay and other crops which in some areas and seasons are kept in open areas after harvest.

The type of crops and the quantity of storage will vary with the season, the price of the crop relative to the general price level of the economy, and the farmers' particular circumstances. The most common pattern is that the quantity of stored crops has a strong inverse relationship with the price of the commodity. For purposes of economic evaluation, it is generally adequate to estimate a long-term average quantity of stored grain with the current normalized prices taken to be the average value of the stored crops. In instances where there is a [illegible] pattern of crop storage that can be related to seasonality of flooding, damage estimates may be computed on a monthly or seasonal basis.

There is no active Federal program that would prohibit the sale of crops that may be contaminated by flooding. However, there is a grading system that is maintained by the U.S. Department of Agriculture, Federal Grain Inspection Service. There are individual grading criteria for eleven grains. For example, corn standards are divided into 6 grades, 1 (highest) through 5, and sample grade, which has minimal market value. Corn grades are established by the percentage of kernels that are broken (an indicator of spoilage); the sample weight, which is the total number of pounds per bushel (an indicator of moisture content); and the proportion of foreign particles in the grain (an indicator of contamination). Values vary by grade and regional market conditions, and are determined by supply and what individual wholesalers are willing to pay after inspecting the grain.

MOVEABLE MACHINERY AND VEHICLES

The greater part of farm machinery used in plowing fields, planting, and harvesting is movable and can be evacuated from vulnerable areas given adequate warning time. The required lead time will vary with the length of the evacuation route and the quantity and mobility of the equipment; but certainly when 12 hours or more of lead time is available, only the costs of evacuating and storing the equipment should usually be considered.

The inventory of movable machinery and equipment can be determined either through a farmstead by farmstead survey or the application of generalized machinery requirement surveys.

The Census of Agriculture has information on the average value of machinery per farm for each county in the United States. The census is published every five years by the U.S. Census Bureau. An alternative approach is the use of generalized machinery investment/acre relationships. These relationships can be computed on a crop-by crop-basis, based on typical management practices in the study area.

Where warning time is estimated to be sufficient to evacuate machinery, inundation damage should not be included in the analysis. The costs of evacuating the machinery may, however, be sufficiently large to be included, especially in areas with frequent flooding or where there are large quantities of machinery in the flood hazard area. Evacuation costs include labor, assessed at the prevailing average hourly farm wage, the physical costs of moving the machinery, and the costs of storing the machinery, if applicable.

When lead time is insufficient to evacuate even movable equipment, depth-damage functions should be applied. The follow considerations should be made in constructing or adapting damage functions:

1. Tractors and other large cultivation equipment will be unaffected until water depth is over 2 feet or .6 meter.
2. Water will reduce electrical or internal combustion engines to scrap value after prolonged flooding.

3. Corrosion will commence any time water sufficiently dilutes, washes away lubricating oil and grease, or even sufficiently dampens some machinery. At the least, this would necessitate thorough cleaning and re-lubrication.

Penning-Rowsell and Chatterton (1977) developed depth-damage functions for various types of movable equipment. They indicate some equipment has very little damage susceptibility, less than 10 percent damage when inundated with up to nearly three feet of water. This includes equipment without electrical parts or gearboxes.

FIXED EQUIPMENT

Most farms only do a minor amount of food processing. Except in the case of a specialized operation, it is rare for a farm to have a large amount of fixed equipment. The major exception is dairy farms, which commonly occupy the broad alluvial floodplains of the Midwest. Other types of fixed equipment may include: mill mixers, corn rollers, automatic feeders, grain driers, and generator/compressors. Depth damage functions for fixed farm equipment should be developed from post-flood examination of similar farm or industrial equipment. The extent of damage to electrical and mechanical equipment should be noted, after allowing time for the effect of corrosion.

FENCES

Fences are heavily susceptible to damage from small amounts of flooding. All livestock areas and many cultivated areas are secured by fences of varying construction. The average installed cost per mile should be determined for each type of fence. Assuming straight-line depreciation, a five-year-old fence with an estimated remaining useful life of twenty years should be assessed at eighty percent of current replacement cost. There are no generally-used depth-damage functions for fences. The susceptibility will vary considerably with type of fence, velocity of flood water, and debris content.

ROADS AND RAILROADS

Farmsteads have a large number of unimproved dirt and gravel roads. These roads are subject to more frequent damage than paved roads, but it costs less to restore them to their pre-flood condition. The costs of labor and the operation of grading machinery are the primary costs of removing debris and leveling road surfaces. State and county highway departments can be contacted to determine typical road construction costs that can be used to determine labor, machinery, and material costs. Care should be taken not to consider improvements that would exceed pre-flood conditions.

Rail damage consists of removal of debris and replacement of silt-contaminated ballast, bridge repair and clean-up, replacement of electric signals and wires, and replacement of mechanical equipment for grade crossings. Again, state and county transportation departments and railroad companies are sources for information concerning costs for repair of flood damage to railroad lines and bridges.

The Corps' Lower Mississippi Valley Division has developed depth-damage relationships for gravel and paved roads for each of its four Districts, i.e., Memphis, New Orleans, St. Louis, and Vicksburg, as well as one rail depth-damage relationship for the entire Division. These are illustrated in Table VI-1. The relationships were published in 1977 and are all based on low velocity events. Any use of these or other figures should be adjusted by application of regional construction price indexes, and annual price index figures, such as the Federal Highway Administration Highway Construction composite index or the Engineering News Record, Construction Cost Index.

TABLE VI-1

LOWER MISSISSIPPI VALLEY DIVISION

ROADS AND RAILROADS DEPTH-DAMAGE TABLES

Water Depth (Feet)	DOLLAR DAMAGES PER LANE (TRACK) MILE								
	Roads								Railroads
	New Orleans		Vicksburg		Memphis		St. Louis		All
	Gravel	Paved	Gravel	Paved	Gravel	Paved	Gravel	Paved	Districts
10 & >	185	197	172	198	184	219	204	267	13,146
9	182	193	169	194	180	214	200	261	12,888
8	178	190	165	191	177	210	196	256	12,636
7	175	186	162	187	173	206	193	251	12,388
6	171	182	159	183	170	202	189	246	12,145
5	168	179	156	180	167	198	185	241	11,907
4	164	175	153	176	163	194	181	237	11,673
3	161	172	150	173	160	190	178	232	11,444
2	158	168	147	169	157	187	174	227	11,220
1	155	165	144	166	154	183	171	223	11,000

DRAINAGE AND IRRIGATION DITCHES

Flooding can similarly contribute to the deterioration of drainage and irrigation ditches by the erosion of embankments and deposition of silt and debris. Some amount of both of these types of problems can be expected to occur any time flood levels exceed drainage ditch embankments or the height of the embankment. These types of damage will increase at least in proportion to the velocity and sediment of the flood water.

OTHER EROSION AND SEDIMENT DAMAGES

Additional concerns include the degradation of crops and pasture areas by the scouring or erosion of topsoil and deposition of debris and sediment. Flood damage includes: 1) costs of restoring the land to the pre-flood conditions, including elimination of weed infestation, removal of rocks and other debris, and regrading of soil, 2) increased costs of cultivation; and 3) long-term or temporary reduction in crop yields.

Erosion and deposition will be intensified in areas with many swells and gullies which would lead to concentration of flows. Costs of land restoration will also be particularly high when there is substantial sediment content, poor water quality, and highly erodible soil. Per acre estimates of land restoration and changes in crops yields can be best made after post-flood investigations.

LIVESTOCK

Damage to livestock can occur in two ways: 1) direct loss due to disease or to the drowning of livestock, and 2) increased costs of livestock production due to the loss of grazing time while pastures are inundated. Loss in the use of pasture areas may also compel the farmer to sell off livestock before it obtains what would otherwise be the optimal weight. Direct loss from the drowning of livestock is rare for most broad alluvial floodplains where twelve hours or more of warning time is available. In cases where ample warning time is available, the evaluator should only include the costs of evacuating and temporarily storing the animals until the floodwaters recede.

Where there is little time for evacuation and there is a serious threat of livestock loss, normalized prices should be used in the evaluation. Normalized prices for livestock are computed annually by the U.S. Department of Agriculture, Economic Research Serivce, and are published by hundred weight in the Corps' _Fiscal Year Reference Handbook_.

PASTURE

The primary effect of pasture damage is to decrease the amount of time that livestock have to graze until the pasture is reestablished. There are also costs to [illegible] debris [illegible]. If flooding occurs at a time [illegible] late fall [illegible]

[illegible]

[illegible] selling the [illegible] weight [illegible] determined by interviewing the farmer to obtain an estimate of the daily costs of feed per grazing animal and the decreased net market value per animal, given the amount of weight gain foregone. The smaller of these two costs should be used.

SEEDS, PESTICIDES, HERBICIDES, AND FERTILIZERS

Stored farm material, if not tightly sealed, may also receive damage far in excess of the flood depth, due to capillary action. Flooding may contaminate farm inventory or cause premature germination of seeds. Fertilizers and other chemicals can, however, withstand even long duration floods if they are wrapped in polyurethane bags or kept in plastic containers, as long as the containers are not punctured, or otherwise damaged, prior to, or during, the flood event.

NON-PHYSICAL LOSSES

EMERGENCY COSTS

The most significant nonphysical losses are the direct costs to federal, state, and local government to protect life and health and avert physical losses, and the administrative costs to oversee disaster relief activities. Cost estimates from previous floods can be obtained from public agencies (e.g., state police and National Guard) and nonprofit organizations (e.g., Red Cross) involved with emergency work. Per unit costs, derived by dividing historic [illegible] flood event, can be used for estimating future [illegible] potential. Of course, intensity of historic costs is required to estimate the damage potential under current price levels.

TEMPORARY RELOCATION AND REOCCUPATION COSTS

Farmstead and other rural occupants may be forced to relocate for extended periods until floodwaters recede and repairs have been sufficiently completed to allow reoccupation. This temporary relocation requires additional lodging, commuting, and food expenses for the relocated household. Reoccupation costs also include the opportunity costs of time spent addressing administrative matters for repair and replacement of property.

TRAFFIC REROUTING

The additional time and travel expense, incurred by drivers forced to make detours because of flooded and/or flood-damaged roads, are NED losses. State Department of Transportation or county public works officials can usually provide information on daily traffic volume, persons per vehicle and alternative (detour) routes for the affected roads. They can also assist in estimating the additional mileage and time that would be incurred using these routes. Average per mile operating expenses for the region, or other nearby area, can usually be obtained from the U.S. Department of Transportation or the American Automobile Association. Minimum wage rates can be used to evaluate lost time unless additional information on traffic composition (e.g., percentage of commercial vehicles) is available to use more appropriate rates.

ADMINISTRATIVE COST OF FLOOD INSURANCE

The administrative costs of the National Flood Insurance Administration are estimated annually by the Federal Insurance Administration and published in the Corps' annual Fiscal Year Reference Handbook. A NED benefit can be claimed for every eligible property taken out of the 100-year floodplain because of the protection offered by a project.

CHAPTER VII

COLLECTING BASIC DATA AND DETERMINING FUTURE CONDITIONS

The purpose of this chapter is to discuss methods to be used in collecting basic data and determining future with- and without-project conditions for the analysis of agricultural flood control projects. The discussion includes considerations in the level of detail required, identifying and delineating damage reaches, determining existing conditions, projecting most likely alternative future conditions, and data collection and sources.

LEVEL OF DETAIL

The level of detail required in collecting basic data and determining future conditions depends on factors such as type of study, available time and money, sensitivity of project formulation/justification to changes in the agricultural benefits, and the availability of data from the study or similar area. Because of the compressed time frame and amount of money available for reconnaissance type reports, the amount of detail required is usually less than what is required for a survey scope feasibility report.

Additionally, the same level of detail is not required for a study where the agricultural benefits are a small percent of total benefits and do not influence project formulation or justification, as is required for one where project justification depends on the agricultural benefits. A lesser level of effort in primary data collection may also be required when data are available for an area with similar cropping patterns, crop budgets, flooding characteristics, and other features.

REACH DELINEATION

One of the first steps in the analysis of any flood control project is the delineation of the damage reaches to be used. Damage reaches are used to define boundaries for data aggregation, analysis, and reporting. Factors that must be considered in identifying reach boundaries include hydrology, soils, land use and management practices. Damage reaches are also delineated based upon reporting requirements, along political boundaries, or where significant differentiation of the nature of damage (for example, urban versus agricultural) occurs. Damage reach delineation requires coordination between economists, hydrologic engineers, and hydraulic engineers.

HYDROLOGY

The hydrology of an area is very important in the delineation of damage reaches. Each reach must be delineated to provide, as closely as possible, an area with homogeneous hydrologic characteristics, such as velocity, sediment content, seasonality, duration, and frequency of occurrence. Damage reaches also require consistent (essentially parallel throughout reach) water surface profiles for the range of flows that can cause significant flood damage potential. Damage reach boundary delineation must also consider the availability of hydrologic data and existing and possible future flood control project locations.

Once a reach is identified and delineated, a reference point (often called an index location) on the stream must be identified (as previously illustrated in Figure IV-2, page IV-8). The index locations are common points where crop damage (area-elevation) is aggregated and hydrologic information (e.g., historic period of record, elevation-frequency, and elevation-area flooded data) are developed. The index location may be anywhere in the reach, but is commonly located where reliable discharge-frequency and water surface profile data may be determined. The identification of the index location also requires close coordination between hydrologists and economists.

SOILS

Damage reaches should be delineated so as to include relatively homogeneous soil capability groupings. This is important because it will be very difficult, if not impossible, to accurately estimate the effects of a project in a reach with widely varying soil capabilities and, therefore, widely varying crop distributions, yields, and production practices.

LAND USE AND MANAGEMENT PRACTICES

Reaches should be delineated so that they include fairly homogeneous land use and management practices. If a reach is found to have significant differences in land use and/or yields and management practices, it should be stratified (that is further divided into subareas or zones) in order to reduce the effect of such variation on the damage analysis. The point or points for stratification should be based on the frequency of flooding (elevation) at which farmers reaction to such factors as risk aversion or soil type show a significant change. These stratification points need to be determined early in the data collection process and should be based on knowledge of the area and initial interviews with farmers and other agricultural experts. Data will be compiled for all stratified segments of the floodplain for purposes of damage analysis.

EXISTING CONDITIONS

Defining and describing existing conditions is a very important step in the analysis of agricultural flood damage. Information needed includes the amount of land in cropland and pasture, the percent distribution of each crop, crop yields, and crop budget data. This information will be collected by reach and by reach segment or zone, as needed for the analysis. Existing conditions are defined as the average conditions that occur during flood-free years (i.e., years in which no floods occurred, but the risk of flooding existed).

LAND USE

A land use study will be conducted to determine the amount of land in various uses (e.g., woods, crops and pasture, urban, and miscellaneous) at various elevations. This information will be developed by reach and will take the form of an elevation-area curve, an example of which is provided in Figure VII-1.

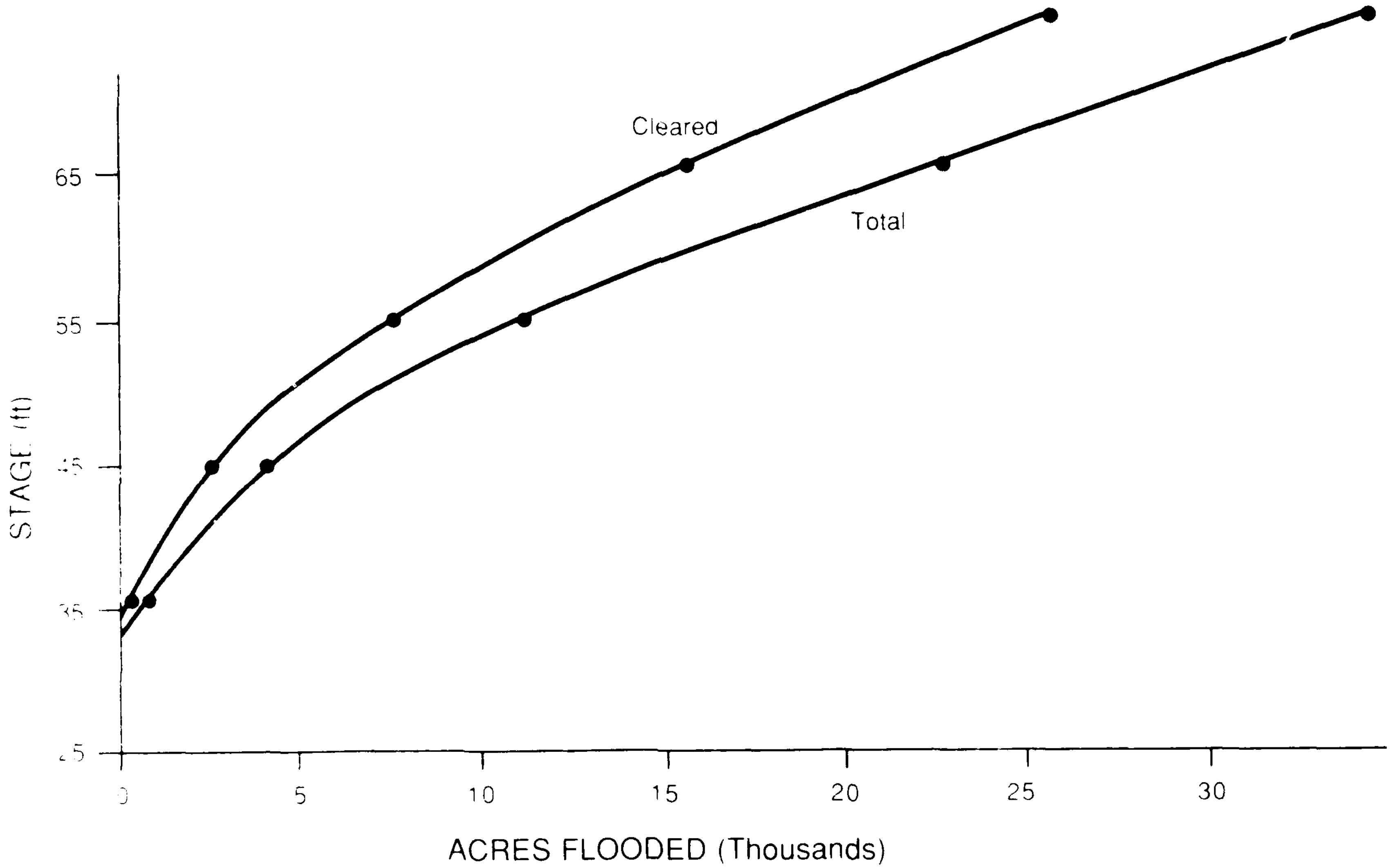

FIGURE VII-1 EXAMPLE STAGE AREA CURVE

Elevation-area curves can be developed from aerial photographs (low or high altitude) and will be referenced to the same index location as the elevation-frequency curves. The US Army Engineer Waterways Experiment Station (WES), in Vicksburg, Mississippi, has developed a computer model that develops elevation-area curves using LANDSAT data, imagery interpretation, and digitization.

CROPPING PATTERNS

The crop distributions occurring in the floodplain under flood-free conditions will be determined. These data will be collected by reach and stratified area as necessary. An example of a typical crop distribution is presented in Table VII-1. An elevation-crop curve for each stratified area can be developed through integration of the percent of crop distribution (Table VII-1) and the cropland elevation-area curves (Figure V-1) for the appropriate areas.

TABLE VII-1

EXAMPLE OF TYPICAL CROP DISTRIBUTION

Crop		Percent Distributions
Cotton		10
Soybeans		50
Wheat		10
Rice		15
Pasture		10
Idle		5
	Total	100

YIELDS

The average yield under flood-free conditions will be determined for each crop grown in the areas being analyzed. The yields under flood-free conditions are very difficult to determine and should be closely scrutinized. The data obtained may be biased, as many other factors (e.g., drought or unusually long or short growing season) may have occurred influencing yields during the period for which data were collected. The yields obtained may need to be adjusted based on knowledge of soil fertility, farming methods, or other cultural factors in the study area. Comparison of collected yield data with those from areas with comparable soils, climatic conditions, and management practices, but without a flood problem, may help in determining the validity of the information collected.

DURATION

The effect of duration of flooding is a very important fact r in determining flood damage to crops which must be addressed during the data collection phase. Factors such as sunlight and temperature also influence the effects of floods of various durations on crops. During hot, sunny weather, short duration floods may cause significant damage, whereas, during mild, cloudy weather, the same flood event might cause very little damage. Since data are not available to accurately simulate daily sunlight, temperature, and duration relationships, damage estimates for various duration floods must be based on average seasonal conditions of temperature and sunlight.

The stage of plant development also determines the effect of various duration flood events on crops. Plant development is usually divided into four stages:

1. Stage I. Nongerminated seed through germinated seed in the crook, but not yet emerged.
2. Stage II. Emerged plant in the furled-leaf stage to five-leaf, or unfurled stage.
3. Stage III. Five-leaf stage to the blooming stage.
4. Stage IV. Fruiting through harvest.

Data on the duration to cause damage must be collected for each crop being analyzed. These data will be collected for each stage of plant development and will be based on average seasonal conditions of temperature and sunlight. Data from previous studies in the same or comparable areas can often be used with minor or no modifications. Plant scientists at the Agricultural Experiment Stations at the state universities can also provide information on the effect of flooding duration on crop damage.

BUDGET DATA

Typical farm budgets must be developed for each crop analyzed. These budgets should be based on the management practices most prevalent in the study area. The budgets should identify each operation employed in producing and harvesting a crop and the average date when the operation is performed. A typical crop budget for cotton is illustrated in Table VII-2. Most of the Agricultural and Forestry Experiment Stations prepare crop budgets annually.

TABLE VII-2

EXAMPLE OF PER ACRE CROP BUDGET FOR COTTON

Operation	Date	Day	Cost
Fixed harvest cost-picker	Jan 1	1	$ 39.26
Stalk shredder	Jan 2	2	3.87
Chisel plow 16 ft (twice)	Mar 1	60	6.29
Disk & incorporate 21 ft	Mar 13	72	6.64
Disk harrow 21 ft	Mar 20	79	2.77
Field cultivate 21 ft	Mar 27	86	1.91
Disk bed	Apr 1	91	2.09
Disk bed & fertilize	Apr 5	95	11.23
Row condition	Apr 10	100	3.16
Plant & Prepare	Apr 25	115	19.99
Cultivate early	May 15	135	3.10
Apply insecticide (ground)	May 22	142	2.83
Cultivate & post (early)	May 29	149	4.65
Cultivate & post (early)	Jun 5	156	6.85
Hand weed control	Jun 12	163	5.30
Cultivate & post (late)	Jun 19	170	5.93
Cultivate & post (late)	Jun 30	181	4.14
Hand weed control	Jul 5	186	5.30
Cultivate & post (late)	Jul 10	191	10.25
Insect scouting	Jul 17	198	3.75
Apply insectide (air)	Jul 19	200	8.19
Apply insectide (air)	Aug 17	229	16.14
Apply insectide (air)	Sep 1	244	8.19
Apply insectide (air)	Sep 11	254	11.56
Apply defoliant (air)	Sep 19	262	7.08
Interest on operating capital	Sep 19	262	10.34
First pick, haul & gin			
1st period	Oct 1	274	28.36
2nd period	Oct 14	287	14.90
3rd period	Oct 21	294	14.21
4th period	Oct 28	301	13.49
Second pick, haul & gin			
1st period	Nov 4	308	6.82
2nd period	Nov 11	315	5.69
3rd period	Nov 18	322	5.69
4th period	Nov 25	329	4.56
		Total	$304.83

EXPECTED GROSS RETURNS	$513.62
PRODUCTION COSTS	304.83
EXPECTED NET RETURNS	$208.79

Prices. Current normalized prices (see footnote, page III-12), derived by the US Department of Agriculture (USDA) will be used to evaluate NED agricultural benefits. These prices are distributed annually by the Office, Chief of Engineers in a Fiscal Year Reference Handbook. For crops not covered by the normalized prices derived by the USDA, statewide average prices over the previous three years may be used.

Production Costs. Production costs will include the costs of equipment ownership and operation; production materials; labor and management; system operation, maintenance, and replacement (OM&R); and interest payments. If costs associated with flood control measures (e.g., on-farm drainage) are included in the project cost analysis, they should be excluded from the production costs in the enterprise budgets.

Purchased inputs will be valued at current market prices. Interest will be computed at the project discount rate. All labor, whether operator, family, or hired, will be valued at prevailing farm labor rates. Management costs will be estimated on the basis of the type of farming operation. The estimate is normally expected to be at least six percent of the variable production cost.

FUTURE WITH- AND WITHOUT-PROJECT CONDITIONS

CROPPING PATTERNS

The most probable cropping pattern(s) expected to exist, with- and without-project will be projected. Where uncertainty exists in probable cropping patterns, alternative projections should be made and the sensitivity of the results on project evaluation tested. If project measures are expected to reduce damage or associated cost problems without a change in cropping patterns, then the current cropping pattern is projected into the future for both with- and without-project conditions. If the project is expected to alter cropping patterns, the most likely crop distribution(s) should be projected for the with-project conditions. It should also be noted that some projects might provide protection (e.g., elimination of soil erosion) that would maintain current cropping patterns that would otherwise be altered under the without-project condition. This should be reflected in the appropriate cropping pattern projections.

YIELDS

Future yield levels with and without the project must also be projected. For some projects, changes in yields might result without any change in production practices (e.g., yields might improve because of more efficient drainage resulting from the project). Because of a reduction in flood risk, a project might also influence changes in farmers' management practices, resulting in changed yields. Such changes can include: increasing production inputs, more effective timing of operations, increased land leveling, and construction of additional drainage or other associated works.

Future yields will also be adjusted to reflect relevant physical changes in soil and water management conditions (e.g., erosion, drainage, water supply, and floodwater runoff). Increases in yields due to future improvements in technology may be included in the evaluation when realization of these yield increases is dependent upon the project. The costs associated with these improvements in technology should also be accounted for in the analysis. Some Agricultural and Forestry Experiment Stations have developed estimates of yield increases that can be expected in the future because of improvements in technology. A publication entitled Economic Indicators of the Farm Sector, Production and Efficiency Statistics provides historical, per acre indices of input and output. These historical data can be used as the basis for projecting changes in yields and production costs resulting from improved technology.

CROP BUDGETS

As described in Chapter III, flood damage can reduce a farmer's net income, not only by directly damaging crops or reducing yields, but also by requiring the farmer to incur increased production expenses. Management practices anticipated under projected with- and without-project conditions must be compared with those for which current crop budgets were derived and adjusted as needed to reflect any anticipated changes in production costs.

DATA SOURCES

A major problem in conducting a satisfactory agricultural flood damage analysis is obtaining quality data for use in the evaluation. Primary data sources are preferable for obtaining specific and accurate information, but using such sources is often too costly or time consuming. Secondary sources are usually less expensive [illegible] must be used in obtaining data that are pertinent to the study area. Reliable sources consulted on a regular basis can be invaluable as providers of necessary information. Some of the general sources for various types of information needed for agricultural damage analysis are summarized in Table VII-3.

TABLE VII-3

POTENTIAL DATA SOURCES BY SUBJECT

Subject	Potential Data Source
Commodity prices (historic, present, and projected)	A, C, E, G, H, K
Crop yields (historic, present, and projected)	A, B, C, E, G, H, K
Land use (historic, present, and projected)	A, B, C, E, G, H
Land values	A, F, G, H, J
Crop damage, erosion, sedimentation	A, B, C, H
Agricultural property damage	A, D, H, I
Crop production (operations, inputs, and costs)	A, B, C, E, H

Sources

A = University Agricultural Extension Services
B = Soil Conservation Service (SCS)
C = Agricultural Stabilization and Conservation Service (ASCS)
D = Farm equipment dealers
E = Growers associations
F = County assessors
G = USDA publications
H = Farmers
I = Insurance companies
J = Realtors and appraisers
K = USDA Economic Research Service (ERS)

INTERVIEWS

Interviews with farmers and other area residents are important primary sources of information concerning the data discussed in this chapter. Interviews should not be confined to only those farmers located within the flood hazard area. Data from otherwise comparable farms located outside the flood hazard area can provide a standard to check, as well as assisting in developing with project projections.

When interviewing the general public, only survey questionnaires that have been approved by the Office of Management and Budget (OMB) should be used. A compilation of OMB-approved questionnaire items available for use by the Corps is available in Approved Questionnaire Items for Collection of Planning Data (US Army Corps of Engineers, 1984). Example questionnaires for collecting needed agricultural data are reproduced in Figures VII-2 and VII-3. These questionnaires can be used in their present form, combined or shortened, as necessary to address specific study data collection needs.

When conducting surveys, the use of appropriate interview techniques is essential to the collection of accurate data. Ideally, the person conducting the interview should have some knowledge of farming practices and problems in the area. Such knowledge may have been obtained academically (e.g., through agricultural courses at a college or university in the area) or through experience. If such knowledge is not available, local agricultural experts, such as cooperative extension agents or soil conservationists, may be asked to assist in conducting interviews with farmers.

All questionnaires should be kept short and scheduled, if possible, so as not to conflict with the farmers' busiest times of the year, usually planting and harvest seasons.

FLOOD DAMAGE – AGRICULTURE

Respondent ______ Years on Farm ______ Farm Location ______ Watershed ______ Reach ______

Flood Date ______ No. of Acres Flooded ______ How frequently do floods of this size occur? ______ No. of Acres Flooded by largest flood ______

Damage to Crops and Pasture From Flood of Above Date

Land Use	No. of Acres	Depth of Flood (Ft.)	Duration of Flood (Hrs.)	Expected Yield/Acre If No Flood	Yield/Acre After Flood	Alternate Crop & Yield/Acre	Additional Production Practices Performed Due to Flood	Production Practices Not Performed Due to Flood

Other Agricultural Property Damage From Flood of Above Date

Item	Type	Quantity	Depth of Flood	Estimated Damage (Dollars)

Estimated Land Damage From Flood of Above Date

Kinds	Acres	Productivity Loss	Remarks

REMARKS

Date of Interview ______

By ______

FIGURE VII-2 EXAMPLE FLOOD DAMAGE QUESTIONNAIRE

LAND USE IN TOTAL FLOOD PLAIN

Crop	No. of Acres	Usual Date for Production Practices				Date too late to Plant
		Land Preparation	Planting	Cultivating	Harvest	

1. What changes in land use have you made due to floods? ______
2. What changes would you make if the frequency of flooding were reduced by half? ______
3. How often do large floods occur? (If the flood described above is a large flood, change this question to small floods.) ______
4. During what seasons are floods most common? ______
5. In addition to the loss in yield described above, was there any damage to quality of crops? ______
6. What damage did this flood do to roads and bridges nearby? ______

Use other side for <u>REMARKS</u>.

FIGURE VII-3 EXAMPLE AGRICULTURAL LAND USE QUESTIONNAIRE

SECONDARY DATA SOURCES

Some very useful secondary data sources include:

1. Agronomists and soil scientists can provide data to help establish yield estimates and critical flood durations.

2. Many universities and the Department of Agriculture Experiment Stations have developed typical enterprise budgets that can be modified to reflect conditions in the area being studied.

3. Soil Conservation Service soil maps, available for every county in the U.S., provide valuable information on soil types, productivity, and other cultural factors.

4. If the market value approach is used, qualified land appraisers, familiar with the productivity of the land under with- and without-project conditions, should be used to estimate land values.

5. The U.S. National Agricultural Library provides comprehensive coverage of worldwide literature on agriculture and related subjects in its AGRICOLA data base. Entries in this data base can be accessed using the Information Retrieval Service available to Corps offices.

DATA VERIFICATION

Regardless of the source of the information obtained, questions should be asked concerning its validity and/or appropriateness for the area under study. The following "check list" is not designed to be exclusive of other factors that may be important in individual study areas. It does, however, represent some of the items that need to be considered in determining the reasonableness of the estimates derived for the study area.

1. Are the land use and yields within the capabilities of the soils in the reach?

2. How do the yields compare with those in similar areas outside the study area? Are there any peculiarities in the study area that would make it differ significantly from otherwise similar areas?

3. Are the yield estimates and crop distribution in balance? If a crop is shown to be highly productive in comparison with other crops, but only a few acres are grown, is there a logical explanation for this apparent economic irrationality?

4. Are the estimated yields and enterprise or crop budgets compatible with the apparent evidence of economic conditions in the area?

SUMMARY

The collection of basic data and the determination of future conditions is the most important step of the entire analysis, because without accurate data on land use, yields, and budgets for the with- and without-conditions accurate evaluations cannot be made. The analysts must familiarize themselves with the conditions of the study area and must collect and analyze the data very carefully.

CHAPTER VIII

ESTIMATING CROP AND NON-CROP BENEFITS

Previous chapters of this manual have described basic concepts (III), setting up and performing an analysis (IV), crop (V) and non-crop damage functions (VI), and methods for collecting basic data and forecasting with- and without-plan conditions (VII). The purpose of this chapter is to illustrate, with some simplified examples, how these concepts and functional relationships are incorporated into the benefit analysis. As an overview, a hand computation example is first presented to illustrate one approach for integrating hydrologic and crop damage functional relationships. Subsequent examples are then used to illustrate the crop and non-crop evaluation procedures described in the P&G.

APPROACHES FOR ESTIMATING AGRICULTURAL FLOOD DAMAGES

There are two general types of approaches for estimating agricultural flood damage; the historical, or period of record, and the frequency methods. The period of record method computes damage based on the historical record of actual flood events. It, therefore, requires a detailed and reliable historic record of continuous hydrologic data. The period of record approach can provide a more detailed level of analysis, including the direct simulation of damage from recurrent flood events that occurred during the same year. The Lower Mississippi Valley Division's Computerized Agricultural Crop Flood Damage Assessment System (CACFDAS) is an example of an existing computerized procedure based on the period of record approach.

With the frequency method, flood damages are calculated for several floods of various sizes. The flood sizes are chosen to represent the distribution of floods in the watershed. Although partial duration frequencies and seasonal weighting of flood events can be directly incorporated into the frequency method, an adjustment must be made to account for recurrent flood events. The Hydrologic Engineering Center's Agricultural Flood Damage Analysis (AGDAM) program is an example of an existing computerized procedure based on the frequency method.

Although the period of record and frequency methods use different approaches for annualizing flood damages, much of the input data, and many of the assumptions and interim analytical routines are the same, or very similar. When selecting an approach for a particular study, consideration should be given to available computerized procedures, hydrologic and agricultural data input requirements, level of detail of analysis required, and study resource constraints.

EXAMPLE OF DAMAGE CALCULATIONS

A simplified hand calculation will be used to illustrate the general analytical steps required. The following is adapted from an example in the AGDAM Users Manual (Hydrologic Engineering Center 1985) and is, therefore, based on the frequency approach.

The example is a manual calculation of the crop damage associated with a specific flood event and subsequent calculation of annualized damages. For this example, the number of variables (seasons, flood hydrograph ordinates, and crop categories) are minimized to simplify the computations and thus more clearly demonstrate basic data requirements and analytical procedures. The problem is to calculate the damage to one crop (corn) that would result from the 20 percent chance flood event in one damage reach. The calculations are based on four seasons - winter, spring, summer, and fall.

BASIC DATA REQUIREMENTS

The basic economic damage and hydrologic data needed for the analysis were derived from previous studies in the area. The information includes: elevation-agricultural area relationships; cropping patterns within the damage reach; crop yields and prices; and potential crop damage functions. Each of these is described below.

The water surface profile elevation-agricultural crop area relationship for the reach is shown in Table VIII-1. The area was obtained from planimetering topographic maps of the reach considering slope in water surface profiles. Aerial photographs and field reconnaissance were used to determine proportions of the total area that were cropped.

Typical cropping patterns within the reach were determined by field reconnaissance, interviews of local farmers, and inspection of aerial photographs for selected time periods over the past two decades. Corn comprises about 50 percent of the agricultural area, with the remainder in wheat and soybeans. The estimated yields, prices, and values per acre of the crops are shown in Table VIII-2.

TABLE VIII-1

ELEVATION - AGRICULTURAL AREA RELATIONSHIPS

Elevation (ft msl)[1]	Agricultural Area (acres)
694	0
700	10
702	50
704	200
706	600
708	1200
710	2500
712	5000

1 feet above, mean sea level

TABLE VIII-2

CROP DATA

Crop	Percent of Agricultural Area	Yield in Bushels per Acre	Price per Unit	Value per Acre
Corn	50	110	$2.75	$302.50
Wheat	25	45	3.25	146.25
Soybeans	25	25	5.00	125.00

Potential crop loss functions for corn were derived from literature review and interviews with farmers and other agricultural-related business persons. The functions were derived from investment costs, profits, and critical dates of the year. Critical dates include: the start of soil preparation, end of cultivation, last date for replant, crop maturity, and beginning and ending of harvest. Based on these data, a relationship of percent loss as a function of the gross value minus harvest costs (100 percent) was developed for days of the year (Figure VIII-1). This relationship represents the maximum potential loss for a given date.

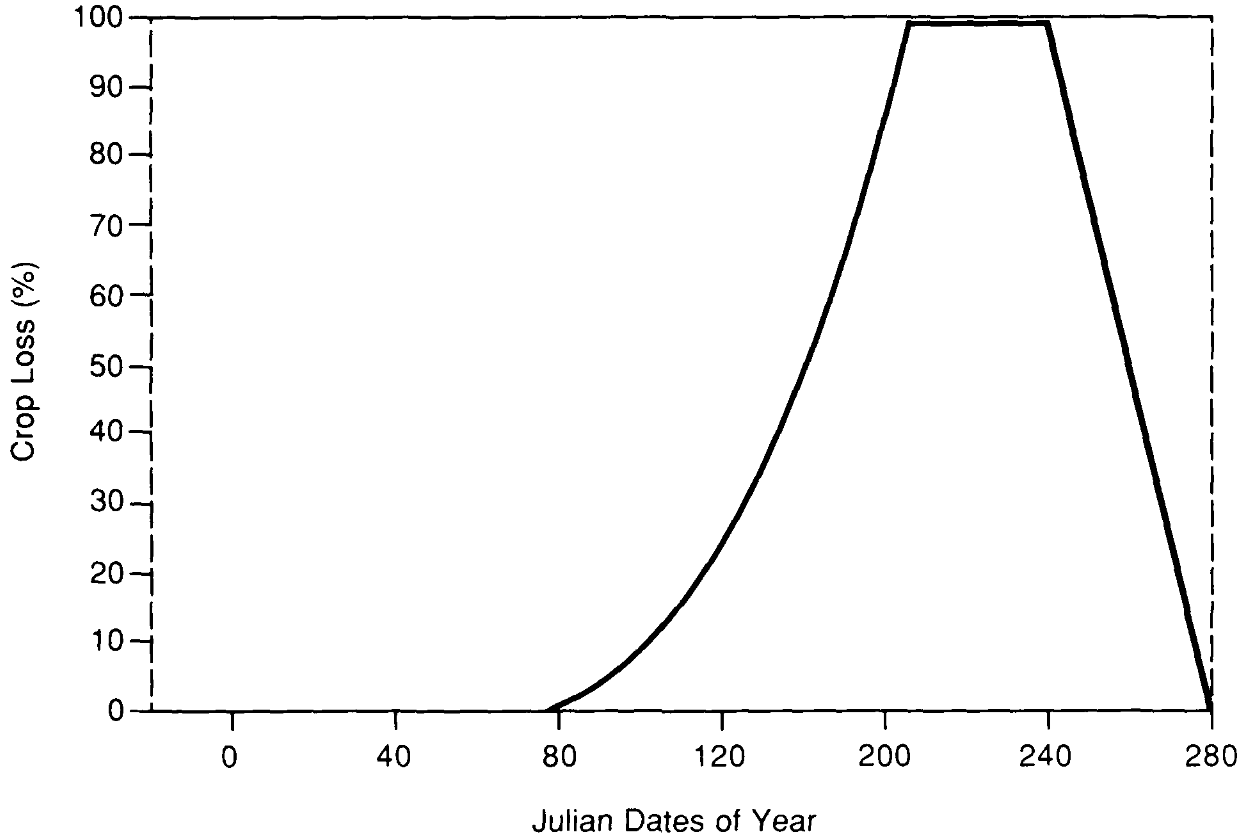

FIGURE VIII-1 EXAMPLE CROP LOSS FUNCTION - CORN

Duration-damage tables (percent loss of the maximum potential loss) were also developed to account for the effects of various flood durations during different seasons of the year. These relationships are summarized in Table VIII-3.

TABLE VIII-3

POTENTIAL PERCENTAGE LOSS OF CROP VALUE FOR CORN

Date	Day of Year	Potential Percent Loss	Percent Loss by Flood Duration 0-Day	1-Day	3-Days	7-Days
31 Mar	90	0	0	0	0	0
30 Apr	120	10	0	10	30	40
30 May	150	30	0	50	70	80
29 Jul	210	90	0	60	90	100
28 Aug	240	100	0	80	100	100
7 Sep	250	100	0	80	100	100
27 Sep	270	0	0	80	100	100

The actual value of potential crop loss is determined by multiplying the 100 percent potential loss value per acre times the percent values of Table VIII-3. From Table VIII-2, the gross value per acre for corn is $302.50, and, for this example, harvests costs are estimated to be $50.00 per acre. The maximum potential loss value per acre is, therefore, $252.50 per acre. The calculated dollar loss values for corn for different durations of flooding and time of year are summarized in Table VIII-4.

TABLE VIII-4

POTENTIAL DOLLAR LOSS PER ACRE FOR CORN

Date	Day of Year	Potential Dollar Loss	Dollar Loss by Flood Duration 0-Day	1-Day	3-Days	7-Days
31 Mar	90	0	0	0	0	0
30 Apr	120	25.25	0	2.52	7.58	10.10
30 May	150	75.75	0	37.88	53.02	60.60
29 Jul	210	227.25	0	136.35	204.52	227.25
28 Aug	240	252.50	0	202.00	252.50	252.50
7 Sep	250	252.50	0	202.00	252.50	252.50
27 Sep	270	0	0	0	0	0

As can be seen from Tables VIII-3 and VIII-4, potential crop losses vary significantly throughout the year. When determining the expected damages for a particular exceedance event, seasonal damages need to be weighted by the probability of the event occurring during that season. The seasons used for the study reach and the proportion of time the 20, 4, and 1 percent chance events occur in each season are shown in Table VIII-5. The seasonal periods used were based on the crop loss function and hydrologic runoff characteristics from throughout the year. The proportion of time the event occurs in each season was estimated from nearby streamgage records.

TABLE VIII-5

PROPORTIONS OF TIME EVENT OCCURS BY SEASON

Season	Period of Year (day)	Proportion of Time Event Occurs		
		20% Event	4% Event	1% Event
Winter	1- 90	10	05	05
Spring	91-180	40	50	50
Summer	181-270	20	15	15
Fall	271-365	30	30	30

A rating curve, which describes the discharge-elevation relationship, was derived from analysis of a range of water surface profiles at the damage reach index location. This curve is shown in Table VIII-6.

TABLE VIII-6

RATING CURVE

Elevation (ft msl)	Discharge (cfs)
694	0
700	150
702	540
704	1,400
706	2,700
708	5,000
710	15,000
712	80,000

A set of flood hydrographs was also developed using rainfall-runoff analysis procedures. The hydrographs were calculated at upstream subbasin outlets and combined and routed through the system. The analysis included calibration of hydrologic parameters, frequency discharge, and volume values to historic events and records. Since damage to crops in the study reach does not occur during the winter (snowmelt runoff) season, the rainfall set of hydrographs were assumed applicable for all seasons. The discharge hydrographs are used in determining the duration of flooding which can have a significant effect (see Tables VIII-3 and VIII-4) on the magnitude of crop damages. Hydrographs developed for the 20, 4, and 1 percent chance frequency events are shown in Table VIII-7.

TABLE VIII-7

DISCHARGE HYDROGRAPHS FOR ALL SEASONS

Time (hrs)	20% Event (cfs)	4% Event (cfs)	1% Event (cfs)
0	0	0	0
12	1000	1700	2800
24	2700	4600	7300
36	1300	3200	5500
48	200	1100	3300
60	0	200	1700
72	0	0	500
84	0	0	0

DAMAGE CALCULATION PROCEDURES

The damage analysis for corn from a 20 percent chance event requires development of the damage potential for each season, calculations of the actual damage by flood events and seasons, and determination of the total event damage from the weighted seasonal values.

Elevation based hydrographs. The conversion of discharge hydrographs to elevation based hydrographs is required to enable calculation of duration of flooding by flood zones. Elevation values for the 20 percent chance event hydrograph of Table VIII-7 were interpolated linearly from the rating curve of Table VIII-6. The resulting 20 percent chance event elevation hydrograph is shown in Table VIII-8.

TABLE VIII-8

20 PERCENT CHANCE FREQUENCY EVENT ELEVATION HYDROGRAPH

(All Seasons)

Time (hrs)	Discharge (cfs)	Elevation (ft msl)
0	0	694.0
12	1000	703.1
24	2700	706.0
36	1300	703.8
48	200	700.3
60	0	694.0

Duration of flooding by zones. Flood zones are used to calculate damage potential that results from different durations of flooding throughout the elevation range. The peak 20 percent chance frequency discharge from Table VIII-8 is 2700 cfs, which corresponds to an elevation of 706.0 feet msl. Therefore, the range of damage potential for corn is from elevation 694.0 to 706.0 feet msl. The division of zones is based on the elevation values of Table VIII-6. The flood zones for analysis are as shown in Table VIII-9.

TABLE VIII-9

FLOOD ZONES 20 PERCENT CHANCE EVENT

Zone	Elevation Range (ft msl)
1	694.0 - 700.0
2	700.0 - 702.0
3	702.0 - 704.0
4	704.0 - 706.0

For this example, the cropping pattern of corn is assumed to start at the invert (zero discharge) of the channel or conveyance path. The more typical situation would be for the start of planting to be above the high bank of the channel.

1. Zone 1 duration. The duration of flooding of zone 1 is assumed to be the average duration over the zone. This is determined by averaging the duration of flooding at the lower and upper elevation limits of the zone, 694.0 and 700.0, respectively. A small discharge is assumed at the lower limit, elevation 694.0, which therefore results in a duration of 60 hours (see Figure VIII-2). The upper limit duration is 60 hours less the rising limb time (T_1) and the receding limb time (T_2), as described below.

Rising and receding limb times are calculated based on the interpolation of time and discharge values. From Table VIII-6, the discharge at elevation 700.0 feet msl is 150 cfs. The discharge from Table VIII-8 at 12 hours is 1000 cfs. Therefore the rising limb time between elevation 694.0 and 700.0 feet msl is:

$$\frac{T_1}{150 \text{ cfs}} = \frac{12 \text{ hrs}}{1000 \text{ cfs}}$$

$$T_1 = \frac{12 \times 150}{1000}$$

$$T_1 = 1.8 \text{ hours}$$

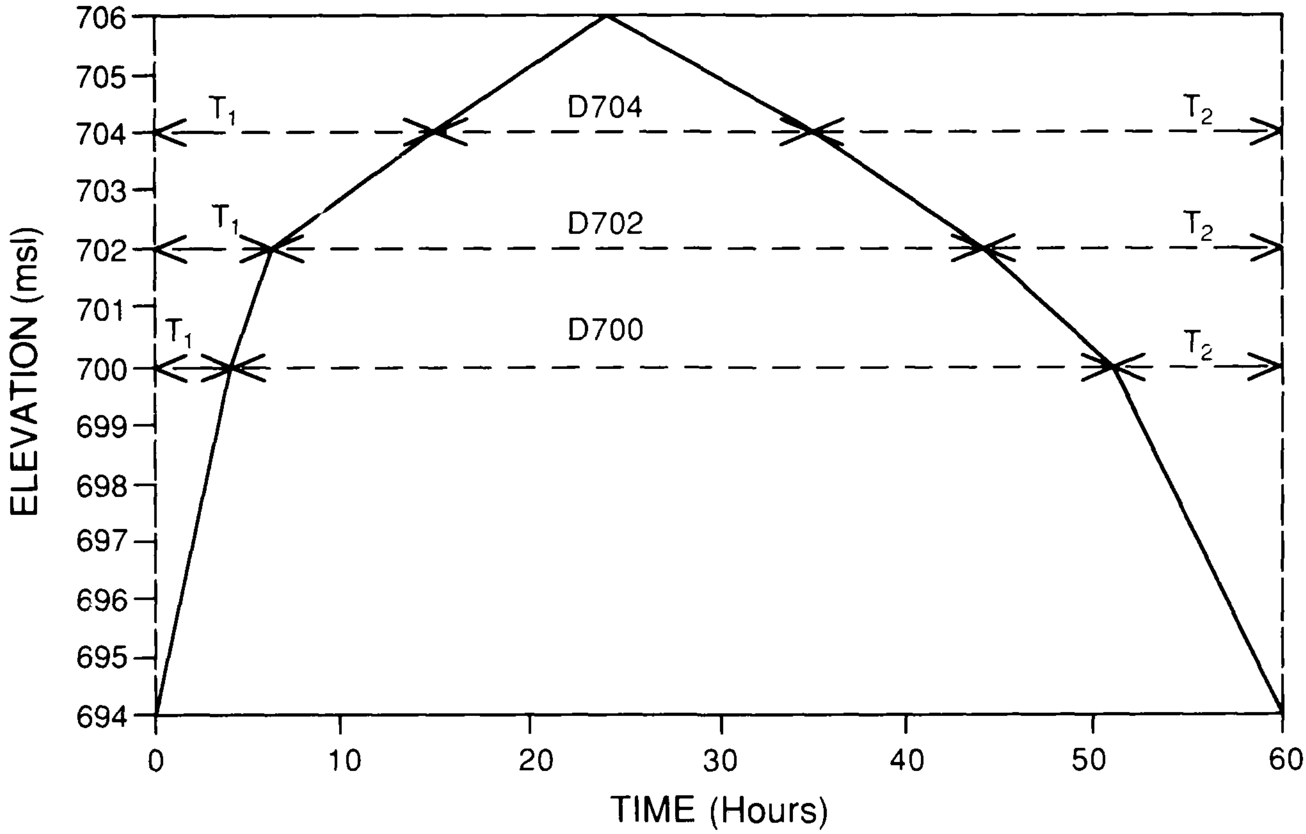

FIGURE VIII-2 ELEVATION HYDROGRAPH

2. Similarly, the value (T_2) associated with the recession limb of the 20 percent chance event at elevation 700.0 feet msl may be estimated by linearly interpolating data from Tables VIII-6 and VIII-8.

$$\frac{T_2}{150 \text{ cfs}} = \frac{60 \text{ hrs} - 48 \text{ hrs}}{200 \text{ cfs}}$$

$$T_2 = \frac{12 \times 150}{200}$$

$$T_2 = 9 \text{ hrs}$$

3. The duration of flooding at elevation 700.0 feet msl, therefore, may be estimated as:

D_{700} = 60 hrs - T_1 - T_2

D_{700} = 60 hrs - 1.8 hrs - 9 hrs

D_{700} = 49.2 hrs

4. The average duration of flooding for zone 1 is the average duration at elevations 694.0 and 700.0 feet msl, or:

D_{z1} = (60 hrs + 49.2 hrs)/2

D_{z1} = 54.6 hrs or 2.275 days

Note: The linear interpolation is performed on discharge, not on elevation values.

5. Similar calculations can be performed for the other flood zones. The results are summarized in the first three columns of Table VIII-10.

Damage calculations. Damage calculations are performed using the crop loss per acre relationships in Table VIII-4 for the seasons shown in Table VIII-5. Damage calculations were not required for the winter nor fall seasons because no damage occurs between Julian days 1 and 90 and between Julian days 271 and 365, respectively (Figure VIII-1).

The damage calculations for the spring season are performed by evaluating the damage potential between Julian days 91 and 180. The average day of the spring season is, therefore, equal to Julian day 135. As previously calculated, the average duration of flooding in zone 1 for the 20 percent chance event is 2.275 days. Damages per acre for the 20 percent chance event for zone 1 are estimated by interpolating between the one and three days duration damage potential (Table VIII-4) for Julian day 135 as illustrated below.

1. Damage of one day duration flooding (D_1) for Julian day 135 is determined by the following:

$$\frac{(D_1 - \$2.52)}{(\$37.88 - \$2.52)} \qquad \frac{\text{Julian Days } (135 - 120)}{\text{Julian Days } (150 - 120)}$$

$D_1 = .5(\$37.88 - \$2.52) + \$2.52$

$D_1 = \$20.20/\text{acre}$

2. Damage for 3 days duration of flooding (D_3) at Julian day 135 is determined in a similar manner:

$$\frac{(D_3 - \$7.58)}{(\$53.02 - \$7.58)} = \frac{\text{Julian Days } (135 - 120)}{\text{Julian Days } (135 - 120)}$$

$D_3 = .5(\$53.02 - \$7.58) + \$7.58$

$D_3 = \$30.30/\text{acre}$

3. The dollar damage per acre of corn in zone 1 for the spring season may be subsequently determined by interpolation of the values for 1 and 3 days duration of flooding as follows:

$$\frac{(D_{2.275} - \$20.20)}{(\$30.30 - \$20.20)} = \frac{(2.275 - 1) \text{ days}}{(3 - 1) \text{ days}}$$

$D_{2.275} = (1.275/2)(\$30.30 - \$20.20) + \$20.20$

$D_{2.275} = \$26.64/\text{acre}$

4. Since zone 1 contains 10 acres of agricultural area (Tables VIII-1 and VIII-9) and 50 percent of the agricultural area is in corn (Table

VIII-2), the damage to corn in zone 1 from the 20 percent exceedance event occurring during the spring season is:

D = \$26.64/acre x 5 acres

D = \$133.20

Similar calculations may be performed for other zones and seasons. Table VIII-10 depicts the results of the computations.

The zonal values are summed to get a total damage by season (Table VIII-10). The seasonal values must be weighted by the proportion of time the 20 percent chance event occurs in each season (Table VIII-5). Total weighted damages (WD) to corn from the 20 percent chance event would be estimated by:

WD = (\$3910 x .40) + (\$32260 x .20)

WD = \$1564 + \$6452

WD = \$8020 (rounded)

TABLE VIII-10

20 PERCENT CHANCE EVENT DAMAGE TO CORN

CALCULATION SUMMARY

Zone	Range in Elevation	Days Flood Duration	Dollar Damages by Season: Winter	Spring	Summer	Fall
1	694 - 700	2.27	0	130	1030	0
2	700 - 702	1.81	0	[illegible]	[illegible]	[illegible]
3	702 - 704	1.21	0	[illegible]	[illegible]	[illegible]
4	704 - 706	.42	0	[illegible]	[illegible]	[illegible]
5	706 - 708	0	0	[illegible]	[illegible]	
		Total		[illegible]	[illegible]	

Similar calculations would be made for several other sized flood events for the damage reach. The combination of estimated damages and the percent chance frequencies for these events describes a damage-frequency relationship. Expected annual damages (EAD) can be derived from the damage-frequency relationship through several alternative procedures: a curve can be drawn through plotted values of corresponding damage and frequency points, and the area under the curve planimetered; a regression equation could be fit to the corresponding damage and frequency points and integrated; or a tabular procedure, as summarized in Table VIII-11, could be used.

TABLE VIII-11

COMPUTATION OF EXPECTED ANNUAL DAMAGE (EAD)

% Chance Frequency	Dollar Damages	Change in Frequency	Average Damage	Contribution to EAD ($)
0	25,070			
		.01	25,070	251
.01	25,070			
		.03	19,880	596
.04	14,690			
		.16	11,355	1,817
.20	8,020			
		.05	4,010	200
.25	0			
	Expected Annual Damage		(rounded)	2,860

The tabular procedure basically assumes a straight line relationship between any two consecutive points on the damage-frequency curve. For example, annual damages associated with the one and four percent chance events were calculated for the damage reach using the procedures described above for the 20 percent chance event. The percent chance frequencies (column 1) and associated damages (column 2) for all of these events are shown in Table VIII-11. Damage was estimated to be zero with the 25 percent chance and more frequent events. The Change in Frequency values in column 3 (e.g., .03) are the differences between any two consecutive frequency points (i.e., .04 - .01) in column 1. Similarly, the Average Damage values in column 4 (e.g., 19,880) are the averages of the estimated damage for the two corresponding events [(i.e., (25,070 + 14,690)/2]. The Contribution to EAD values (column 5) are the products of the Change in Frequency (column 3) and Average Damage (column 4) values, and their sum is the estimate of expected annual damages.

Although the frequency approach was used in the above example, the calculation of damage for individual events would be very similar when using the period of record approach. The primary difference in the approaches is that when using the period of record approach flood damage is computed for all damaging events (i.e., flows exceeding some minimal non-damaging level) that have been recorded during the period of record, not for just a few selected synthetic events. Average annual damages are computed by summing the damage for all events and dividing by the number of years in the period of record. Weighting for seasonal (Table VIII-10) and individual event frequencies (Table VIII-11) is not needed when using the period of record approach. Of course the computational process is much larger, since damage must be computed for a much larger number of events; however, computer programs, such as the Lower Mississippi Valley Division's CACFDAS program, are available to accomplish the actual computations.

EVALUATION PROCEDURE: CROPS

STEP 1: IDENTIFY LAND USE AND CROPPING PATTERNS

As previously illustrated in Figure II-1, the P&G describes a nine-step process for evaluating the benefits to crop production. Step 1 is to identify land use and cropping patterns with and without a plan. Procedures for collecting the basic data and making these forecasts were described in Chapter VII. Under the P&G, lands in the project area are to be separated into two categories for analytical purposes: lands on which the cropping pattern is the same with and without the plan being evaluated, and lands on which there would be a change in cropping pattern with the plan. For the former, the analyst proceeds to Step 2, determine damage reduction benefit; while for the latter to Step 3, select evaluation method for evaluating intensification benefit.

STEP 2: COMPUTE DAMAGE REDUCTION BENEFITS

For land on which the cropping pattern would not change, farm budget analysis is used to determine the change in net income, or net returns, with and without a plan. No changes in cropping pattern, (i.e., crop distribution), does not mean changes in yields or management practices are not to be considered. Comparisons with yields during flood-free conditions and with yields and management practices on lands with flooding characteristics similar to those anticipated under with-plan conditions (Chapter VII) are used to project with-project yields and management practices in Step 1.

Net returns without the plan are the gross value of production (expected yields times prices) less production costs less expected annual flood damage.

Similarly, net returns with the plan are the gross value of production under the with plan conditions less with plan production costs less any residual damage. Project benefits are the difference in net returns under with- and without-project conditions.

If no changes in crop yields or management practices are anticipated, then EAD prevented is the estimate of the project's annual equivalent benefit. If complete flood protection is provided, then the estimate of EAD under the without-project condition is the estimate of project benefit. When the project provides less than complete flood protection, residual damage is estimated using the same procedures as for the without-project condition, but with the changed hydraulic data. The project benefit is the difference in EAD under the with- and without-project conditions.

In the above example, if a project was to provide complete protection from future flooding and no changes in future yields or production practices were anticipated, the average annual project benefit for corn would be equal to $2,860, the EAD under without-project conditions (see Table VIII-11). Usually, agricultural projects will provide less than complete flood protection and residual damage must be estimated. If the EAD is estimated to be $750 to corn under the with-project conditions, the average annual benefit is $2,860 less $750, or $2,110, again assuming no change in future cropping patterns, yields or production practices.

Although reductions in the frequency of flooding may not change cropping patterns, changes in production practices and yields will often occur. Farmers will often change their method of operation (e.g., increase the use of fertilizer) when the risk from flooding is reduced. In addition, changes in the frequency of flooding can also lead to changes in soil conditions that will directly impact on crop yields. These changes will often not occur instantaneously with the installation of a project, but gradually over time. Proper discounting procedures are needed to properly account for these changes in benefit flows.

Continuing the previous example, assume current and projected yields, production costs and EAD under with- and without-plan conditions have been estimated as shown in Table VIII-12. No changes are anticipated under the without-project condition for the life of the project, 100 years. The only changes anticipated during the base year under with-plan conditions, are reductions in EAD. However, over time, improved soil conditions and changes in production practices are expected to increase yields, gross revenues, production costs, and residual damage. The change is expected to occur during the first 10 years and then stabilize for the remainder of the life of the project.

TABLE VIII-12

CALCULATION OF NET INCOMES PER ACRE (AND TOTAL) FOR CORN

	Without-Plan	With-Plan	
	Base Year	Base Year	Years 10-100
Yield (bu)	110	110	120
Price per bu	$2.75	$2.75	$2.75
GROSS INCOME	$302.50	$302.50	$329.50
Variable costs	$140.00	$140.00	$145.00
Fixed costs	$75.00	$75.00	$77.00
Operator labor & mgmt	$30.00	$30.00	$32.00
Expected annual damages	$3.80	$1.00	$1.10
TOTAL COSTS + DAMAGES	$248.80	$248.75	$255.10
NET INCOME (per acre)	$53.70	$56.50	$74.70
Acres	x750	x750	x750
TOTAL (rounded)	$40,300	$42,400	$56,000

Expected annual benefits are the differences between net incomes for the with- and without-plan conditions for each year of the project life. For the base year, the expected annual benefits are $42,400 less $40,300 or $2,100, and for years 10 through 100, $56,000 less $40,300, or $15,700. Assuming a constant rate of growth between the base year and year 10, the annual flow of benefits is illustrated in Figure VIII-3. (Note: A detailed discussion of discounting procedures is provided in the National Economics Development Procedures Manual Urban Flood Damage, currently in print.)

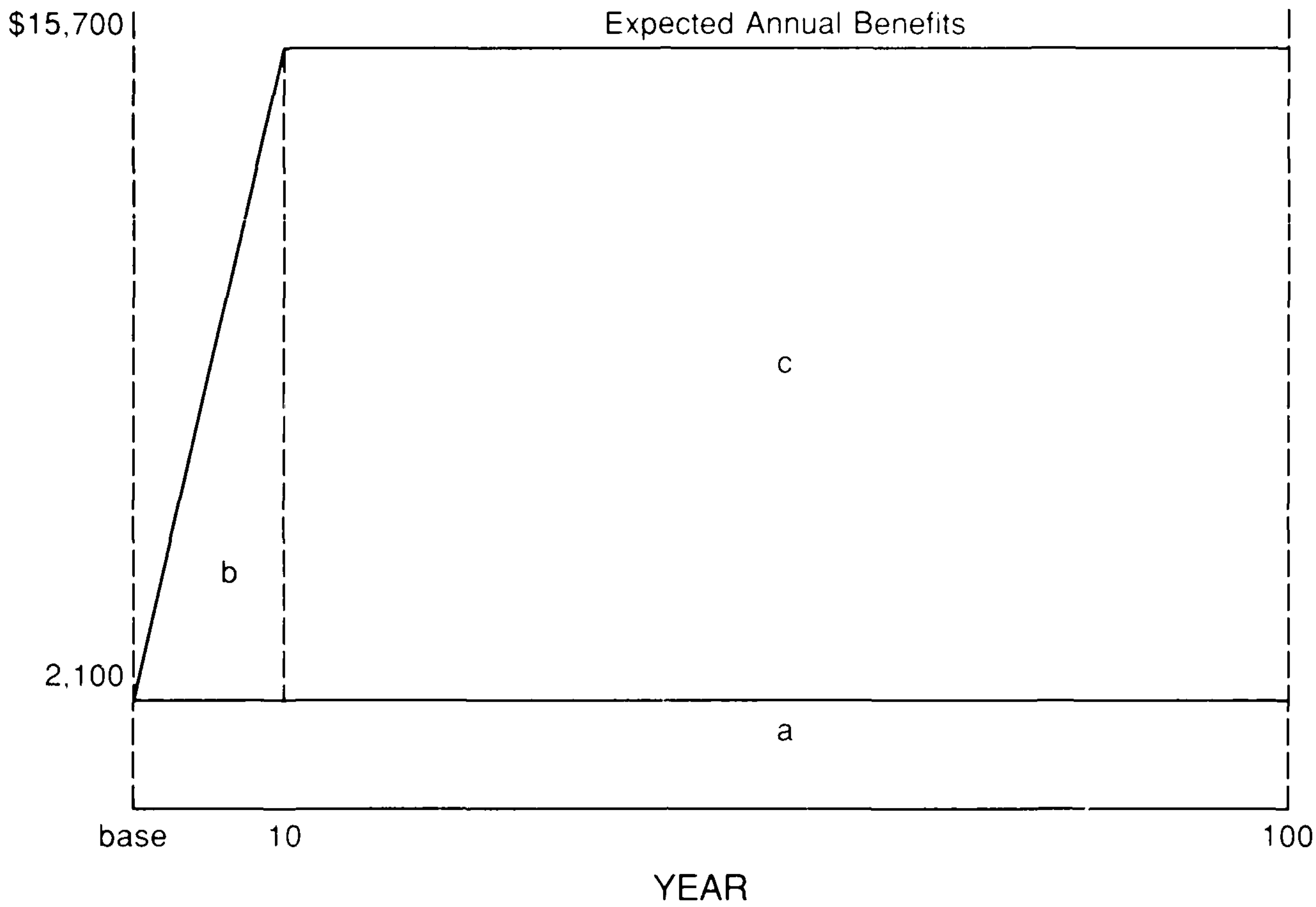

FIGURE VIII-3 EXPECTED ANNUAL BENEFITS - CORN

Assuming an 8 percent interest rate, the contribution to average annual benefits for areas a, b, and c are approximated by:

1. a = base year change in net income ($2,100) multiplied by 1.0.

2. b = per year increase of the change in net incomes between the base year (year 1) and year 10, [($15,700 - $2,100)/9], multiplied by the present value factor for a uniform gradient series for ten years, muitiplied by the amortization or capital recovery factor for 100 years.

3. c = increase of net income between the base year and year 10 ($15,700 -$2,100), multiplied by the present worth factor for a uniform annual series for 90 years, multiplied by the present worth factor of a single payment in year 10, multiplied by the capital recovery factor for 100 years.

4. The computation at 8.0 percent is:

a = $2,100 x 1.0	=	$2,100
b = $1,511 x 27.977 x 0.08004	=	3,384
c = $13,600 x 12.488 x 0.4632 x 0.08004	=	6,297
Average Annual Benefit (rounded)	=	$11,800

The above example has illustrated some of the factors and calculations that must be considered when computing agricultural damage reduction benefits. The example was simplified for illustrative purposes. For example, as discussed in Chapter VII, it is often necessary to stratify the damage reach by elevation when differences in the duration and frequency of flooding would result in significantly different yields per acre for different zones of elevation. However, although such considerations would change the computational complexity of the problem, they would not change the general procedural process illustrated above.

STEP 3: SELECT EVALUATION METHOD FOR INTENSIFICATION BENEFITS

For land on which the cropping pattern would change, either the farm budget analysis or land value analysis is selected as the method for measuring intensification benefits. The farm budget analysis method is described in Steps 4 through 8, while land value analysis is described in Step 9.

STEP 4: DETERMINE WHETHER OTHER CROPS ARE TO BE TREATED AS BASIC CROPS

If the projected change in cropping pattern increases the acreage in production of "other" (i.e., non-basic) crops, the following test (from the P&G) must be applied to determine whether the production of these crops is constrained by the availability of suitable land in the Water Resources Council subassessment area (ASA). If there is a land constraint, these crops should be treated as if they were basic crops in the benefit analysis.

1. Select a representative sample of farm operations on lands comparable to project lands under the with-project condition.

2. Determine the respective acreages of basic and other crops for each farm operation.

3. Compute the proportion of other crop acreage to total acreage for each farm in the sample.

4. Use farm budget analysis to identify the top 25 percent of sample farms based on highest net income. The average (mean) of the proportions of other crop acreage to total acreages on these top farms is defined as the "optimal proportion."

5. Use standard statistical tests to determine whether or not the optimal proportion is significantly greater than the mean proportion from the individual farms in the remainder of the sample. If it is not significantly greater, then the production of other crops can be considered to be constrained by the availability of suitable land in the ASA and can be treated as basic crops. If it is significantly greater, it can be inferred that the production of other crops is constrained by the limited market for the crop in question, and only efficiency benefits (P&G Step 8) are computed for the other crops.

As an example, the most probable cropping pattern for a ten thousand acre damage reach under with- and without-project conditions is shown in Table VIII-13. The with project conditions forecast an increase of 5000 acres in production of dry beans, which is not a basic crop. A representative sample of eight[1] farms in the ASA with lands comparable to project lands is selected to determine whether or not the production of other crops is limited by the availability of suitable lands in the area. Crop distributions, and proportions of other crop acreage for these farms are shown in Table VIII-14.

TABLE VIII-13

FORECASTED CROPPING PATTERN FOR EXAMPLE REACH

Without-Plan		With-Plan	
Crop	Acres	Crop	Acres
Wheat	5,000	Alfalfa	1,500
Idle	5,000	Corn	3,500
		Dry beans	5,000
	10,000		10,000

[1]Only eight farms are being used to simplify the illustrative example. It is recommended that a minimum sample size of 20 farms be used in application.

TABLE VIII-14

CROP DISTRIBUTION FOR SAMPLE FARMS

	Farms							
Other Crops	1	2	3	4	5	6	7	8
Dry beans	210	195	240	170	220	200	150	190
Basic Crops								
Corn	200	205	50	185	150	150	65	110
Alfalfa	100	105	200	125	100	100	115	120
TOTAL (all crops)	510	505	490	480	470	450	430	420
Proportion Other Crops	.41	.39	.49	.35	.47	.44	.35	.45

An analysis of farm budgets indicates that farms 1 and 5 in Table VIII-14 represent the top 25 percent of farms in this sample. The mean proportion of other crops from these two farms, [(0.41 + 0.47)/2 = 0.44], determines the "optimal proportion" to be used in this study. The mean proportion for the remaining farms in the sample is 0.41, [(.39 + .49 + .35 + .44 + .35 +.45)/6].

The student "t" distribution can then be used to test whether or not the optimal proportions exceeds the sample mean proportion by a statistically significant amount. Since the test is for whether or not the optimal proportion is significantly greater than the sample mean proportion, a one-tailed test is used. If the optimal proportion does not exceed the other sample proportion by an amount greater than an upper bound derived by an application of the t statistic, the hypothesis that the proportions are not significantly different is accepted, and the other crops can be treated as basic crops.

The test statistic = $m_o - m_s$, where:

m_o = "optimal" mean proportion and

m_s = mean proportion from the rest of the sample.

This statistic, equal to 0.03, (0.44 - 0.41) in this example, is compared to an upper bound:

$$= t \times s \times \sqrt{\frac{1}{n_o} \times \frac{1}{n_s}}$$

where:

t = Student's t value, obtained from table of values available in most statistics books.

n_o = number of farms in "optimal farm" sample.

n_s = number of farms in remainder of farm sample.

s = estimate of the standard deviation of the test statistic:

$$= \sqrt{\frac{(x_{io} - m_o)^2 + (x_{is} - m_s)^2}{(n_o + n_s - 2)}}$$

where:

x_{io} = individual farm proportions in "optimal farm" sample and

x_{is} = individual farm proportions in remainder of farm sample.

To calculate s:

x_{io}	$x_{io} - m_o$	$(x_{io} - m_o)^2$
.41	-.03	.0009
.47	.03	.0009
		.0018

x_{is}	$x_{is} - m_s$	$(x_{is} - m_s)^2$
.39	-.02	.0004
.49	.08	.0064
.35	-.06	.0036
.44	.03	.0009
.35	-.06	.0036
.45	.04	.0016
		.0165

$$s = \sqrt{\frac{.0018 + .0165}{(2 + 6 - 2)}} = .055$$

The t value is selected for a one-tailed test at the 90 percent confidence level. The degrees of freedom are 6 ($n_o + n_i - 2$), in this example, so that the corresponding t is 1.440. The comparison becomes:

$$m_o - m_s = .03$$

$$t \times s \times \sqrt{\frac{1}{n_o} + \frac{1}{n_s}} = 1.440 \times .055 \times \sqrt{\frac{1}{2} + \frac{1}{6}} = .065$$

Since the test statistic, 0.03, is less than the upper bound, the optimal proportion is not significantly different from the sample mean. Other crops, in this case, can be treated as basic crops, and the analyst proceeds to Step 5. If the difference in proportions was greater than this upper bound, for example was 0.08, it would imply that the availability of suitable land did not limit the production of other crops. Only efficiency benefits, Step 8, would be estimated for the other crops within the project area.

It should be noted that the above process, as described in the P&G, assumes that the other crops are already being grown in the ASA. If the project will result in a new crop(s) being introduced into the ASA, market analysis or some other technique is required to determine whether or not there is a marketing advantage or some other economic rationale to support projections of future production within the ASA.

STEP 5: DETERMINE LIMIT ON ACREAGE OF OTHER CROPS THAT MAY BE TREATED AS BASIC CROP ACREAGE

The optimal proportion of other crops identified in Step 4, is used to determine the maximum acreage of other crops in the project area that may be treated as basic crops in the benefit analysis. The project area of the previous example (Table VIII-13) is 10,000 acres. The optimal proportion of other crops was found to be 0.44. Multiplying 10,000 acres by 0.44, indicates a maximum of 4,400 acres of other crops could be treated as basic crops. The projected cropping pattern under the with-plan condition contains 5,000 acres of the other crops, dry beans. Based on the optimal proportion, only 4,400 acres of other crops can, therefore, be treated as basic crops (Step 7) in the analysis. Efficiency benefits will be determined for the remaining 600 acres as described in Step 8. In this example, if the projected acreage of other crops was 4,400 or less, all of the other crop acreage would be treated as basic crops.

STEP 6: PROJECT NET VALUE OF AGRICULTURAL PRODUCTION WITH AND WITHOUT THE PLAN

Information from farm budget analysis is used to estimate the net value of agricultural production under with- and without-plan conditions. Estimates of expected annual flood damages under both with- and without-plan conditions must also be considered. Examples of the use of these data in estimating both intensification benefits for basic crops and other crops treated as basic crops, and efficiency benefits for the remaining other crop acreages, are described in Steps 7 and 8, respectively.

STEP 7: COMPUTE INTENSIFICATION BENEFITS FOR ACREAGES OF BASIC CROPS AND OTHER CROPS TO BE TREATED AS BASIC CROPS

Intensification benefits are defined in P&G as the change in net income between the without-project condition and conditions with an alternative plan.

For the example area, incomes and costs have been estimated for both with- and without-plan conditions and are summarized in Table VIII-15. Again, in this example, agricultural activity is projected to remain constant throughout the project life under without-plan conditions, with some increases in yields and production costs during the first 10 years under with-plan conditions.

TABLE VIII-15

COMPUTING NET INCOME FOR INTENSIFICATION BENEFITS

	Without-Plan	With-Plan	
	Base Year ($1000)	Base Year ($1000)	Years 10-100 ($1000)
4,700 acres wheat	564	-	-
4,700 acres idle	0	-	-
1,500 acres alfalfa	-	345	375
3,500 acres corn	-	1,050	1,120
4,400 acres dry beans	-	1,342	1,540
GROSS INCOME	564	2,737	3,035
Variable costs	254	1,302	1,450
Fixed costs	132	640	705
Operator labor & mgmt	85	325	350
Expected annual damage	2	25	30
TOTAL COSTS & DAMAGE	473	2,292	2,535
NET INCOME	91	445	500

As noted above, the intensification benefits are the differences in net income with- and without-plan. Average annual benefit can be derived from the values in Table VIII-15, similarly to those derived for the corn only example in Table VIII-12 and Figure VIII-3. The base year expected annual benefit is $445,000 - $91,000, or $354,000. The expected annual benefit with the plan will rise through year 10 when it will equal $409,000 ($500,000 - $91,000). The average annual benefit computations are:

1. Base year change in net income ($354,000), multiplied by 1.0.

2. Per year increase of change in net income between the base year and year 10 [($409,000 - $354,000)/9], multiplied by the present worth factor for a uniform gradient series for 10 years, multiplied by the capital recovery factor for 100 years.

3. Increase in net returns between the base year and year 10 ($409,000 - $354,000), multiplied by the present worth factor for a uniform annual series for 90 years, multiplied by the present worth factor of a single payment in year 10, multiplied by the capital recovery factor for 100 years.

4. The computation at 8 percent is:

a = $354,000 x 1.0	=	$354,000
b = $6,111 x 27.977 x 0.08004	=	13,684
c = $55,000 x 12.488 x 0.4632 x 0.08004	=	22,464
Average Annual Benefit (rounded)	=	$389,100

This completes the analysis of benefits for lands with increased acreage of basic crops and other crops treated as basic crops.

STEP 8: DETERMINE EFFICIENCY BENEFITS

The P&G defines efficiency benefits as a special category of intensification benefits, namely the benefits from the shifting of the production of other crops, not treated as basic crops, to the project area. Included in efficiency benefit calculations are:

1. The loss of net income from any agricultural production displaced from the project area;

2. The difference between the cost of producing the crops in the project area and the cost of producing them on other lands in the ASA; and

3. The net income that would accrue from production of an appropriate mix of basic crops on those other lands.

The first component of the efficiency benefit calculation is the loss of net income from agricultural production displaced by the plan. In the above example, 600 acres of other crops (dry beans) will not be treated as basic crops. Under without-plan conditions, 300 of these acres are in the production of wheat and 300 are idle (Tables VIII-13 and VIII-15). The average net return per acre for this composition of land use can be derived from Table VIII-15. That is, 9,400 acres of land under the without-plan condition yields $91,000 in net income, or appproximately $10 per acre. The loss of net income from the existing land use of the 600 acres is, therefore, approximately $6,000 per year.

The computations for the reduction in production costs for the example plan area are summarized in Table VIII-16. Appropriate yields per acre and production costs per unit would be derived during Step 1 from farm budget analysis, literature reviews, and interviews of local farmers and other agricultural specialists. Because of probable differences in yields per acre between the project area and other areas within the ASA, production costs are estimated on a per unit, rather than a per acre, basis. Production costs for the project area must include any expected residual damage if the plan being evaluated will not provide complete flood protection.

TABLE VIII-16

EXAMPLE OF COMPUTATIONS - SAVINGS IN PRODUCTION COSTS

	Years	
	Base	10-100
Acres	600	600
Yield in project area (cwt per acre)	17.5	20.0
TOTAL PRODUCTION (cwt)	10,500	12,000
Production costs + EAD ($ per cwt)		
In ASA	15.20	15.20
In project area	14.40	14.30
PRODUCTION COST SAVINGS	0.80	0.90
TOTAL PRODUCTION COST SAVINGS	$8,400	$10,800

It is generally assumed, for purposes of analysis, that the shift of production of other crops not treated as basic crops to the project area will leave an "equivalent area" of production elsewhere in the ASA for production of an appropriate mix of the 10 basic crops adaptable to the area. The "equivalent area" is determined by dividing the estimated production of the other crops that will occur in the project area (Table VIII-16) by the average yields for these crops on the ASA lands from which they would be shifted. Assuming an average yield of 14 cwt per acre of dry beans in the ASA throughout the study period, 750 acres (10,500/14) in the base year, and 857 acres (12,000/14) in years 10 through 100, would be available in the ASA for production of an appropriate mix of basic crops.

Again using data that would have been collected and analyzed during Step 1, the net income per acre for the appropriate mix of basic crops in the ASA is estimated to be $20. The annual increases in net income for this new production of basic crops is $15,000 in the base year (750 x 20) and $17,140 in years 10 through 100 (857 x 70).

The tabulation of the various components of the efficiency benefit analysis is summarized in Table VIII-17.

TABLE VIII-17

EXAMPLE OF TABULATION OF EFFICIENCY BENEFITS

	Year	
	Base	10-100
Loss of net income in project area	$(6,000)	$(6,000)
Savings in production costs	8,400	10,800
Net income from basic crops in ASA	15,000	17,140
TOTAL	$17,400	$21,940

Computation of the average annual benefit is similar to previous benefit categories, that is:

a = 17,400 x 1.0	=	$17,400
b = [(21,940 - 17,400)/9] x 27.977 x 0.08004	=	1,130
c = (21,940 - 17,400) x 12.488 x 0.4632 x 0.08004	=	2,102
Average Annual Benefit (rounded)	=	$20,600

This completes the farm budget analysis method for measuring intensification benefits.

STEP 9: LAND VALUE ANALYSIS

The alternative approach for estimating intensification benefits is land value analysis. When using this approach, land appraisals should be based on market values rather than capitalized income values. Procedural steps of the land value analysis identified in the P&G are:

1. Obtain appraisals of the current market value of lands that would benefit from the plan. Where values differ significantly, divide lands into appropriate categories (see discussion of stratification in Chapter VII).

2. Obtain and appropriately adjust appraisals of non-project lands in the ASA that are comparable to lands in each category of project lands and that will have water conditions similar to those under with- project conditions for each alternative being evaluated. Adjust appraisals for:

a. Facilities and other capital improvements that are not present on project lands. For example, subtract the current market value of improvements such as investments in orchards.

b. In the case of irrigation projects, the value of water costs incurred by the operator. These water costs include both payments to outside suppliers and the cost of self-supplied water. Use the project discount rate to calculate the present value of these costs and add it to the appraised value of the comparable lands.

c. Other factors that may affect the value of land include types of crops grown, distance to urban areas, availability of transportation facilities and utilities, zoning regulations, and special property tax rates. Adjustments may be achieved by using totally comparable parcels of lands; collecting a sample large enough to average out differences; statistical means such as regression analysis; or the use of qualified land appraisers.

3. Subtract the current appraised values of project lands (1) from the adjusted value of comparable lands (2).

4. Annualize the value intensification benefit (3) at the project discount rate.

An example of the use of the land value method is summarized in Table VIII-18. In this example, the project area contains 10,000 acres currently appraised at $800 per acre. There is little variation in land values within the project area; further stratification is not required. The present value of project lands is, therefore, $8,000,000.

TABLE VIII-18

EXAMPLE OF CALCULATIONS FOR LAND VALUE ANALYSIS

	$/acre	Acres	Total
(1) Current value of project lands	800	10,000	$ 8,000,000
Comparable lands			
Current appraisal	1,500	-	-
Capital improvements	(125)	-	-
Value of water costs	350	-	-
(2) Adjusted appraised value	1,725	10,000	$17,250,000
(3) Present value intensification benefit (2 - 1)			$ 9,250,000
(4) Average Annual Benefit (3 x 0.08004)			$ 740,400

Comparable lands in the ASA are currently appraised at $1,500 per acre. Differences in capital improvements between project and comparable lands are primarily land clearing and leveling. Using farm budget analysis, the value of these improvements is estimated to be $125 per acre. The plan being evaluated will provide irrigation benefits as well as flood protection. Again, farm budget analysis is used to measure the annual water costs ($28 per acre) incurred by operators on the comparable lands. The present value of these costs is estimated by multiplying the annual cost by the appropriate present worth factor for a uniform annual series. Based on a 100 year project life and an 8 percent discount rate, the present value of the costs of water is $350, ($28 x 12.494). It is further assumed, in this example, that a large enough sample of comparable lands was used to control for other factors that may affect the value of land.

Using the information described above, the adjusted appraised value of land (Table VIII-18) is estimated to be $1,725 per acre, or a total of $17,250,000, for the with-project condition. The present value of the intensification benefit is the difference between with- and without-project land values, or $9,250,000. Again, the capital recovery factor is used to derive the average annual benefit, or $740,400 in this example.

SUMMARY: CROP EVALUATION PROCEDURES

Although not as complex as most actual planning studies, the above examples illustrate the basic evaluation procedure for crops. In some instances, the examples may have been even more detailed than required for a project study. This was done purposely to illustrate all aspects of individual components of the evaluation. For instance, in the example used to illustrate Steps 7 and 8 above, net income under the without-project condition was estimated separately for the 9400 acres of land that would be replaced by basic crops and other crops treated as basic crops, and the 600 acres that would be replaced by other crops. One combined estimate could have been made for the 10,000 acres under the without-project condition in this example without changing the overall results.

EVALUATION PROCEDURE: NON-CROP

OTHER AGRICULTURAL PROPERTIES

The term "other agricultural properties" is described in the P&G as physical improvements associated with various farm enterprises and the agricultural community. These include rural residential, commercial and industrial buildings; barns, equipment sheds, and grain bins; fences, drainage ditches, roads and bridges; and equipment. Other properties should also include stored crops, if they haven't been considered in the crop analysis. Key steps in determining damages to these properties include:

1. Inventory damageable improvements. Identify the location, type, number, and value of other agricultural properties within the area that are subject to damage. In the case of properties such as rural residential, commercial, and industrial, the construction type, first floor elevation and value of contents should also be determined. This information is most easily obtained through field reconnaissance and interviews of farmers.

2. Determine damage to improvements. The determination of damages to floodplain improvements will be based on historical data and/or simulation.

3. Determine average annual damage to improvements. Use appropriate data to determine average annual damage to improvements. For example, use depth-damage relationships for each reach, integrated with hydrologic data, to develop average annual flood damage with and without the plan. Include consideration of the frequency and duration of the damage. Use appropriate discounting factors to derive average annual estimates.

The integration of depth-damage and hydrologic frequency data for other properties is basically the same as previously described for crops. However, except for stored crops, the seasonal occurrence of flooding is generally not considered important and adjustments are not made for recurrent flooding in a given year. Annual frequency curves are generally sufficient for the analysis of "other properties" damage.

For stored crops, although the depth-damage relationship may not vary throughout the year as with crops under production, the amount of crops stored can vary significantly. The seasonal probability of flood events, therefore, needs to be considered in the analysis of damages to these properties.

ASSOCIATED AGRICULTURAL ENTERPRISES

Associated agricultural enterprises are defined in the P&G as economic activities that may be affected by changed water supply or water management conditions. An example of this type of damage is delay in spring planting on floodfree lands because of flooding of access roads. Damage prevented by a plan is measured as the changes in net income under the with-and without-plan conditions. Again, it is measured with the same basic procedures as used for evaluating crops, integrating the appropriate hydrologic and economic data.

EVALUATION PROCEDURE: OFF-SITE SEDIMENT REDUCTION

Usually, the average annual damage for sediment removal from such facilities as roads, culverts and channels can be calculated by summing historical costs, converted to a constant dollar basis, for a representative number of years, and dividing by the number of years of record. It is important to learn the source of the sediment being removed, so that the effectiveness of the proposed plan in reducing the sediment damage can be estimated. The estimated difference in damage with and without the project is the benefit.

The increased cost of providing goods and services (e.g., additional treatment costs for removing sediment from municipal water) can also be used to evaluate potential damage. Usually, the monetary evaluation of such damage can be made by obtaining, from municipalities or industrial concerns, water treatment expenditures made to correct for the damaging effects of sediment, or estimates of damage to machinery and reductions in quality of product.

In many instances, water is treated to remove the sediment content, as well as to correct for other conditions affecting water use. In such instances, only the additional treatment costs made necessary because of sediment should be used in evaluating sediment damage. For example, assume an existing water user reported $6,000 in average annual expenses for water treatment, but $5,200 of this was for the removal of other chemicals that would not be affected by any alternative plan. The maximum without-project damage for the removal of sediments is then $800, which is also the average annual benefit if the plan eliminates all problems from sedimentation for this water user. However, if some problems from sedimentation remain, an estimate of the average annual water treatment costs for sediment removal under with-project conditions must be estimated and subtracted from the $800 to estimate the benefit of the plan.

CHAPTER IX

REPORT DOCUMENTATION

PLANNING REPORTS

As noted in Chapter II, the concepts and procedures described in this manual are primarily used in implementation and other plan formulation and evaluation studies. The results and findings of such studies are usually documented in planning reports. Basic standards for the organization, format, and content of such reports are established in ER 1105-2-60; flexibility of presentation is provided, however, for studies of varying scope, complexity, and subject matter.

TYPES OF REPORTS

Generally, two categories of planning reports may be produced: feasibility or reevaluation reports. Feasibility reports, for which an NED agricultural benefit analysis may be appropriate, include: Survey Reports, Legislative Phase I General Design Memoranda, and Section 216 Reports. They also include reconnaissance, feasibility and detailed project reports completed under the Continuing Authority Program. Reevaluation reports represent those resulting from preconstruction planning and engineering studies. Reports completed under other Planning Programs might also include the results of an NED agricultural benefit analysis.

REPORT CONTENT AND ORGANIZATION

FEASIBILITY REPORTS

Each feasibility report documents the logic of the plan formulation process. As such it needs to be a complete, but concise, decision-making document. On studies of broad scope and complexity, the report may include a concise summary of plan formulation; in which case detailed plan formulation will be contained in an appendix. Other appendices, except as may be necessary to contain required coordination materials, should not be used. Technical details should be presented in supporting documentation (described below).

Final feasibility reports recommending that no Federal actions or plans be authorized shall be organized generally in the same manner as those recommending Federal action. However, such reports may be abbreviated to the essential information needed to support the recommendation, consistent with the level of study and analysis made in arriving at the findings.

REEVALUATION REPORTS

Preconstruction planning and engineering studies which recommend postauthorization changes by Congress are considered feasibility type reports. They should be organized, to the extent appropriate, in the same manner as feasibility reports. More flexibility is allowed for those reevaluation studies which do not seek Congressional postauthorization approval, in which case they should be organized and detailed at a level commensurate with their findings.

SUPPORTING DOCUMENTATION

Supporting documentation, which is prepared and reproduced separately, is to augment the feasibility or reevaluation reports with more detailed data and analysis. It is not intended to be read alone, but rather with the appropriate planning report. Support documentation shall include engineering, design, and cost material; economics material; and environmental material. Economics material shall contain details of any projective analysis and of the derivation of the economic data for plan formulation. It shall also include a detailed explanation of the benefits included in the report it supplements.

DETAIL AND DISPLAY

DETAIL

The amount of detail required in a report is a variable governed primarily by the objective of fully supporting the essential analyses and conclusions of the study. Clarity in the report enables reviewers to understand the rationale for conclusions and recommendations. Since the report requires input from many different technical specialists, extensive coordination is required to insure a consistent and logical presentation. Design and other technical features need only be adequate to establish general technical feasibility and an adequate, but approximate, sizing and costing of plan features.

DISPLAYS

Displays, such as maps, graphs and tables often represent a very useful and interesting means of presenting a variety of information that would be too cumbersome or complex to present in textual form. These displays are encouraged where they are useful in assisting the reader in understanding the logic and decision-making process that have led to the study recommendations.

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